AD-653 965

MEMORANDUM
RM-5187-PR
APRIL 1967

A PROGRAM FOR CALCULATING RADIATION FLOW AND HYDRODYNAMIC MOTION

H. L. Brode, W. Asano, M. Plemmons, L. Scantlin and A. Stevenson

This research is supported by the United States Air Force under Project RAND—Contract No. F44620-67-C-0045—monitored by the Directorate of Operational Requirements and Development Plans, Deputy Chief of Staff, Research and Development, Hq USAF. Views or conclusions contained in this Memorandum should not be interpreted as representing the official opinion or policy of the United States Air Force.

DISTRIBUTION STATEMENT
Distribution of this document is unlimited.

The RAND Corporation
1700 MAIN ST • SANTA MONICA • CALIFORNIA • 90406

PREFACE

An important tool in weapon effects research is the numerical integration of the differential equations of motion for high temperature, high pressure gases. Computer programs which describe hydrodynamic motion and which can accommodate radiation transport have been helpful in describing blast effects, fireball growth, high explosive detonation waves, shock tube experiments, bubble expansions, radiation blow-off phenomena, thermal radiation phenomena, high altitude effects, and underground explosion initial phases.

Such programs have existed at RAND in various but increasing degrees of sophistication for the past 14 years. Many reports on blast waves, fireballs, etc., have presented results of such calculations. Currently, several other organizations use similar programs, but many more would enjoy the capability if such a code were generally available and easily applied.

This report attempts to answer a portion of that need by describing in detail a program designed for ease of application to a wide variety of problems. This program has evolved from earlier versions (by Brode), and is the product of the present authors' efforts over the past three years. Simplicity and generality are often mutually exclusive objectives. The compromises made in this computer program have tended to favor generality rather than simplicity on the supposition that it is easier for a user to simplify by dropping subroutines and unwanted features than to invent new routines in order to handle each new problem.

SUMMARY

This report contains a numerical program for solving hydrodynamic flow and radiation transport problems in the diffusion and grey-body approximations. The program is appropriate to the solution of explosion and shock wave problems, and to the study of high explosive or nuclear fireballs, hot gas dynamics, deflagrations and detonations, bubble phenomena, shock tube flows, and can be adapted to a host of other dynamics problems. It is restricted to plane, cylindrical, or spherical symmetry.

The report offers (1) a description of the assumed physical model, (2) a rationale' for the difference equations and integration techniques used in the mathematical formulation, (3) a complete set of flow diagrams for the program and its subroutines, (4) a listing of the code, (5) two illustrative example calculations for hydrodynamics and for radiation flow, and (6) helpful hints for checking and running versions of the program.

ACKNOWLEDGEMENTS

This program is the work of many people, and is the end result of a series of previous programs to which even more people contributed. We wish to express our gratitude to these many contributors and earlier workers, and to acknowledge the support of the Computer Science Department as well as the Physics Department at RAND. The early programming efforts were well begun by Richard Grote, advised and supervised by Ivan Finkle, and contributed to by Jane Richardson. We are further indebted to the Computer Science Department for having forsaken the IBM-7090 for the present 7040-7044 computer system three years ago, since re-programming would otherwise not have been necessary and this streamlined version might not have been written for general use.

With no intent to minimize the efforts of any of the many contributors, we would like to single out a few others whose involvement was more than casual. Glen Nance has been a staunch advocate of the work and has reviewed this report and tried out the program. Hannah Wright patiently copied all the flow diagrams, and Alice Smith typed and lashed the whole report together.

CONTENTS

CONTENTS (Continued)

I. INTRODUCTION

This is a world full of dynamics and transient phenomena, and our efforts to cope with and to better understand the physical forces and reactions associated with some of the high pressure, high temperature features have become both extensive and intensive. We search for theories to describe such widely differing time-dependent processes as occur in atmospheric re-entry of space vehicles or ballistic missiles, in nuclear explosions, stellar energetics, or lightning strokes. We look for rather precise descriptions for the dynamic properties of many such problems, even where the situation calls for coupled radiation and hydrodynamic flow treatment. In the absence of adequate analytic solutions, numerical procedures have grown to such sophistication as to be able to accommodate much of the physics involved and to include both greater realism and detail in treating boundary conditions, material properties, and geometrical factors. It is now practical to solve a wide variety of radiation and hydrodynamic flow problems by means of computer programs for numerical integration of differential formulations.

The object of this memorandum is to describe in detail one such numerical program. The program is capable of calculating in one space dimension (spherical, cylindrical, or plane symmetry) hydrodynamic motions including shocks. Radiation diffusion, grey-body or other radiation losses, and energy sinks or sources are simultaneously calculable with this code.

With such a program, calculations can be run which provide a reasonable approximation to the blast and thermal phenomena from nuclear or high explosive detonations. It can compute the responses of simple targets to blast and/or thermal radiation loads. It can predict some deep underground or underwater explosion phenomena, and can be used for transient blow-off and ablation descriptions. The program has been used to investigate shock flows down tunnels, the dynamics of lightning strokes, shock interactions, explosive dynamics in cavities, in space, and in a variety of materials and environments. In addition, shock and radiation flow characteristics can be studied

in reflection or transmission normal to interfaces - between air and water, between water and soil, or between various metals and/or other solids (treated as compressible fluids).

The general mechanisms for integrating the partial differential equations that govern the phenomena of radiation diffusion and hydrodynamic motions are approximately the same for all these types of investigations. The chief differences lie in the fixing of different initial and boundary conditions and in finding appropriate equations of state and opacities for the materials involved. Many of these latter problems have been minimized in the present program, and much of the pain and special programming usually required to set up a new problem can be avoided. The provision for simplified selection of output variables and display of results also makes it easier to get the most out of each problem.

However, the basic computational methods are similar to those of previous codes developed by one of us (Brode).

II. PHYSICAL ASSUMPTIONS AND MATHEMATICAL FORMULATION

A description of the dynamics of an explosion can be obtained from the solution of a set of nonlinear, partial differential equations which represent the conservation of mass, momentum, and energy in some symmetry. These conservation laws may be expressed mathematically in several ways, but are generally formulated in terms of either Eulerian or Lagrangian coordinates. The Eulerian form is an expression of the conservation laws as viewed from coordinate systems fixed in space, and the Lagrangian form is an expression of the same conservations in terms of a fixed set of masses or gas particles. A solution in the Eulerian case may represent the history of a blast wave at a fixed point, while in a Lagrangian system a solution may describe the experience of each particle (or an initially identified volume or mass of gas) as it moves about. Lagrangian (i.e., mass) coordinates are used in the present program.

Most of the currently useful methods for obtaining numerical solutions to problems in hydrodynamics (with or without radiation flow) employ a finite difference technique in which the motions are followed from some initial time to subsequent times through a series of finite time increments and over a set of discrete mass or space differential elements. The equations that govern this iterative integration procedure approximate the differential equations of flow and are called difference equations.

DIFFERENTIAL EQUATIONS

In terms of the variables explicitly treated in this program, expression of the conservation of mass takes the following differential form:

$$\begin{aligned} \frac{1}{\rho} = V &= \frac{1}{3}\frac{\partial R^3}{\partial m} && \text{(spherical)} \\ &= \frac{1}{2}\frac{\partial R^2}{\partial m} && \text{(cylindrical)} \\ &= \frac{\partial R}{\partial m} && \text{(plane)} \end{aligned} \tag{1}$$

$$= \frac{1}{\delta} \frac{\partial R^{\delta}}{\partial m}, \qquad \delta = 1,2,3 \tag{1}$$

in which ρ represents density (V, specific volume), R a radius or spherical dimension, and m the mass.

It is understood that unit length is included in the volume of cylindrical symmetry, and unit area is included in the volume for plane geometry. The mass (m) is defined as the mass per steradian (Mass/4π) in spherical symmetry ($m = \int_0^r \rho r^2 dr$), while m is mass per radian per unit length (Mass/$2\pi\ell$) in cylindrical symmetry ($m = \int_0^r \rho r dr$), and is mass per unit area (Mass/ℓ^2) in plane symmetry ($m = \int_1^r \rho dx$).

The conservation of momentum in differential form appears as

$$\frac{\partial u}{\partial t} = - R^{\delta-1} \frac{\partial}{\partial m} (P+Q), \tag{2}$$

in which u is a particle or gas velocity, P represents pressure, Q is the artificial viscosity pressure, and t represents the time. The artificial viscosity is a convenience first introduced by Von Neumann and Richtmyer(1) for numerical treatment of shock waves. Its effect is to diffuse a shock front and thus avoid the paradoxical situation of discontinuities or sharp shock fronts running through discrete mass elements. A discontinuity in hydrodynamic parameters requires special treatment in finite difference numerical schemes in order to avoid extreme oscillations and instabilities. The artificial viscosity not only avoids special routines, but automatically accommodates all shocks, even multiple shocks wherever and whenever they occur. At the same time, with some care in selection of problem parameters such as zone size and artificial viscosity amplitudes, the spread of shocks can be held to a practical minimum and so not degrade the accuracy of results.

The artificial viscosity form originally considered (in plane geometry) by Von Neumann and Richtmyer was

$$Q = -\frac{(C\Delta m)^2}{V} \frac{\partial V}{\partial t} \left| \frac{\partial V}{\partial t} \right| , \qquad (3)$$

in which C is an arbitrary constant, dimensionless, and of value near unity. As this form indicates, for compressions (i.e., when $\partial V/\partial t$ is negative), a positive viscous pressure is generated, which has a magnitude proportional to the square of the rate of compression and the square of a mass element Δm.

Restricting viscous contributions to compressions only leads to a modified form[2]

$$Q = -\frac{(C\Delta m)^2}{2VR^{2(\delta-1)}} \frac{\partial V}{\partial t} \left[\frac{\partial V}{\partial t} - \left| \frac{\partial V}{\partial t} \right| \right] , \qquad (4)$$

in which we have included a dimensional factor to maintain C as dimensionless in cylindrical and spherical systems.

For weak shocks, this quadratic form tends to generate serious oscillations behind a shock front. A linear viscosity addition may aid in damping these oscillations. An appropriate linear form is similar:

$$Q' = -\frac{C'\Delta m}{2VR^{\delta-1}} \left[\frac{\partial V}{\partial t} - \left| \frac{\partial V}{\partial t} \right| \right] . \qquad (5)$$

A statement of this energy balance in differential form reflects the second law of thermodynamics

$$\frac{\partial E}{\partial t} + P \frac{\partial V}{\partial t} = -Q \frac{\partial V}{\partial t} - D - \frac{\partial L}{\partial m} , \qquad (6)$$

where the terms on the left represent an adiabatic relation between rates of change of internal energy (E) and the rate at which compressional work is done. The right hand side includes the dissipative viscosity term which provides the necessary entropy change in shocks. The D-term symbolizes a depletion rate, or (for negative values) an energy input rate.

The final term $(\partial L/\partial m)$, a luminosity gradient, represents the flow of energy in the diffusion limit. The luminosity itself is defined as the areal flux per unit angle, where the area is $R^{(\delta-1)}$ and the black body flux is $(c\lambda/3)(\partial aT^4/\partial R)$. Thus, one may define the luminosity as

$$L = R^{2(\delta-1)}/k)\ (\partial T^4/\partial m), \tag{7}$$

in which the Rosseland mean free path (λ) has been replaced by 3V/ack, a is the radiation constant (see p. 9), and Eq. (1) has been used. The quantity k is related to the usual Rosseland mean opacity (K_R) by $k = 3K_R/ac$, and c is the velocity of light.*

In addition, it is necessary to describe the thermodynamic properties of the material, i.e., some constitutive relation between specific internal energy, pressure, and density for hydrodynamics. Radiation problems also require that an opacity (k) and temperature (T) be defined and related to the other thermodynamic variables. These equation of state functions can be expressed in various forms, but the basic form employed in this program expresses energy, pressure, and opacity as functions of temperature and specific volume (or density), i.e., E(T,V), P(T,V), k(T,V).

DIFFERENCE EQUATIONS

Figure 1 denotes the particular choice of notation and concentration of variables at mass points and time points. In the particular system represented in Fig. 1 the mass is identified with the half points in the "j" variables, the time is centered at the half points in the "n" variable, and the various quantities such as the velocities, radii, specific volumes, pressures, and energies are identified at the times and mass points indicated in the diagram. With such an identification it is possible to translate the differential equations into difference equations which largely deal with centered quantities. That is, each difference equation is balanced about the same time point and the same mass point in order to minimize the numerical errors in the approximation of differentials by finite differences. A common procedure is to begin, as in Eqs. (8-13), to

*For some physical problems it is important to note that this form does not account for retardation, and energy may transport faster than the speed of light.

develop at time n + 1 a new velocity and then to find a new radius for each j point. From the new radii one can define a new density or specific volume, and from the change in density, an artificial viscosity at the new time. In these equations subscripts (j or $j\pm\frac{1}{2}$) and superscripts (n, $n+\frac{1}{2}$, or n+1) indicate definitions of each particular quantity at those discrete times and masses.

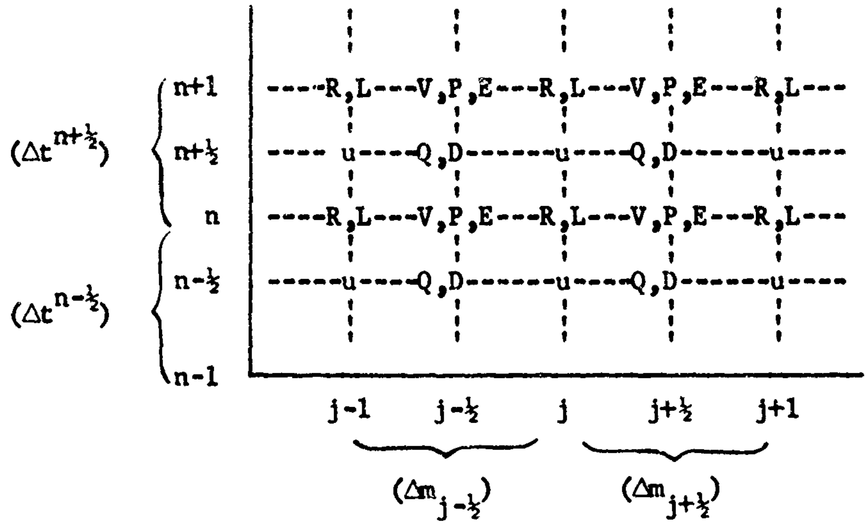


FIG. 1--Lagrangian difference grid for numerical calculation

First:

$$u_j^{n+\frac{1}{2}} = u_j^{n-\frac{1}{2}} - \frac{\Delta t^n}{\Delta m_j} (R_j^n)^{\delta-1}\left[P^n_{j+\frac{1}{2}} - P^n_{j-\frac{1}{2}} + Q^{n-\frac{1}{2}}_{j+\frac{1}{2}} - Q^{n-\frac{1}{2}}_{j-\frac{1}{2}}\right], \qquad (8)$$

in which

$$\Delta m_j = \tfrac{1}{2}\,\Delta m_{j+\frac{1}{2}} + \tfrac{1}{2}\,\Delta m_{j-\frac{1}{2}}, \qquad (9)$$

and

$$\Delta t^n = \tfrac{1}{2}\,\Delta t^{n+\frac{1}{2}} + \tfrac{1}{2}\,\Delta t^{n-\frac{1}{2}}. \qquad (10)$$

Then

$$R_j^{n+1} = R_j^n + u_j^{n+\frac{1}{2}}\,\Delta t^{n+\frac{1}{2}}, \qquad (11)$$

and

$$V^{n+1}_{j-\frac{1}{2}} = \frac{(R_j^{n+1})^{\delta} - (R_{j-1}^{n+1})^{\delta}}{\delta\,\Delta m_{j-\frac{1}{2}}} = \frac{1}{\rho^{n+1}_{j-\frac{1}{2}}}. \qquad (12)$$

The artificial viscosity becomes

$$Q_{j-\frac{1}{2}}^{n+\frac{1}{2}} = \frac{C_1(\Delta m_{j-\frac{1}{2}})^2 (V_{j-\frac{1}{2}}^{n+1} - V_{j-\frac{1}{2}}^{n})^2}{(V_{j-\frac{1}{2}}^{n+1} + V_{j-\frac{1}{2}}^{n})(\Delta t^{n+\frac{1}{2}})^2 \left\langle\frac{R_j^{n+1} + R_{j-1}^{n+1}}{2}\right\rangle^{2(\delta-1)}}$$

$$+ \frac{C_2\, \Delta m_{j-\frac{1}{2}} \left| V_{j-\frac{1}{2}}^{n+1} - V_{j-\frac{1}{2}}^{n} \right|}{(V_{j-\frac{1}{2}}^{n+1} + V_{j-\frac{1}{2}}^{n})(\Delta t^{n+\frac{1}{2}}) \left\langle\frac{R_j^{n+1} + R_{j-1}^{n+1}}{2}\right\rangle^{\delta-1}} , \qquad (13)$$

for $V^{n+1} < V^n$, and

$$Q_{j-\frac{1}{2}}^{n+\frac{1}{2}} = 0 \qquad \text{for} \qquad V^{n+1} \geq V^n .$$

It is in the energy equation alone that radiation enters (except radiation pressure which can contribute to the momentum only at exhalted temperatures). For hydrodynamics only, the energy equation can be written as

$$E_{j-\frac{1}{2}}^{n+1} = E_{j-\frac{1}{2}}^{n} + (\tfrac{1}{2}P_{j-\frac{1}{2}}^{n+1} + \tfrac{1}{2}P_{j-\frac{1}{2}}^{n} + Q_{j-\frac{1}{2}}^{n+\frac{1}{2}})(V_{j-\frac{1}{2}}^{n} - V_{j-\frac{1}{2}}^{n+1}) . \qquad (14)$$

RADIATION DIFFUSION

When radiation diffusion is included, the luminosity as defined in Eq. (7) becomes in difference form

$$L_j^n = \frac{(R_j^n)^{2(\delta-1)}\left[(T_{j-\frac{1}{2}}^n)^4 - (T_{j+\frac{1}{2}}^n)^4\right]}{(k\Delta m)_j^n} . \qquad (15)$$

The opacity is averaged with the mass increments and reduced by the factor ac/3 in which c is the speed of light and a is the radiation density constant (7.62×10^{-15} erg/cm^3/deg^4).

$$(k\Delta m)^n_j = \tfrac{1}{2}\Delta m_{j-\frac{1}{2}}\, k^n(T^n_j, V^n_{j-\frac{1}{2}}) + \tfrac{1}{2}\Delta m_{j+\frac{1}{2}} k^n(T^n_j, V^n_{j+\frac{1}{2}}) \ , \qquad (16)$$

$$k = \frac{3}{ac}\, K_R = \frac{3}{ac}\, \frac{V}{\lambda} \ .$$

The opacity is calculated for the material to the left of the point j for $k^n(T^n_j, V^n_{j-\frac{1}{2}})$ and for the material to the right of the point j for $k^n(T^n_j, V^n_{j+\frac{1}{2}})$. The temperature T^n_j is defined as $\left[\tfrac{1}{2}(T^n_{j+\frac{1}{2}})^4 + \tfrac{1}{2}(T^n_{j-\frac{1}{2}})^4\right]^{\frac{1}{4}}$. This procedure provides a reasonable opacity at interfaces between materials of very different opacity, and does not add undue complexity when the materials are the same.

EXPLICIT RADIATION DIFFUSION

For an explicit scheme of including radiation diffusion (one which has an explicit stability limitation to the size of time increment allowed), the energy equation becomes

$$E^{n+1}_{j-\frac{1}{2}} = E^n_{j-\frac{1}{2}} + (P^{n+\frac{1}{2}}_{j-\frac{1}{2}} + Q^{n+\frac{1}{2}}_{j-\frac{1}{2}})(V^n_{j-\frac{1}{2}} - V^{n+1}_{j-\frac{1}{2}}) + \frac{\Delta t^{n+\frac{1}{2}}}{\Delta m_{j-\frac{1}{2}}}(L^n_{j-1} - L^n_j) - D^{n+\frac{1}{2}}_{j-\frac{1}{2}} \ , \qquad (17)$$

in which $D^{n+\frac{1}{2}}_{j-\frac{1}{2}}$ is a source or sink term yet to be specified.

Some iterative converging solution of Eq. (17) is necessary in which values of $P^{n+\frac{1}{2}}_{j-\frac{1}{2}} = (P^{n+1}_{j-\frac{1}{2}} + P^n_{j-\frac{1}{2}})/2$ and E^{n+1} are sought which satisfy both Eq. (17) and the equation of state E(P,V) or E(T,V), P(T,V). In this explicit form, such iterative convergence is limited to the two variables $E^{n+1}_{j-\frac{1}{2}}$ and $P^{n+1}_{j-\frac{1}{2}}$, all other quantities being of fixed value for that step. When a new energy and pressure have been derived, a new temperature $(T^{n+1}_{j-\frac{1}{2}})$ also exists, and so, ultimately, new opacities and luminosities can be computed for the

next time cycle.

The set of equations (Eqs. 12-17) together with the equations of state and opacities form a set of equations whose solution for "new" values of each variable at all of the mass points can be directly obtained by successively evaluating each equation beginning with j = 0 and proceeding through the maximum j-point, or through all the "active" zones.

IMPLICIT RADIATION DIFFUSION

The implicit diffusion treatment is a form in which the luminosities are treated as centered at the midpoint in time (n+½) rather than taken at the previous time (n) as in the above explicit form in Eq. (17). Thus the form of the energy equation becomes

$$E^{n+1}_{j-\frac{1}{2}} = E^{n}_{j-\frac{1}{2}} + \left(\tfrac{1}{2}P^{n+1}_{j-\frac{1}{2}} + \tfrac{1}{2}P^{n}_{j-\frac{1}{2}} + Q^{n+\frac{1}{2}}_{j-\frac{1}{2}}\right)\left(V^{n}_{j-\frac{1}{2}} - V^{n+1}_{j-\frac{1}{2}}\right)$$
$$+ \frac{\Delta t^{n+\frac{1}{2}}}{2\Delta m_{j-\frac{1}{2}}}\left(L^{n+1}_{j-1} + L^{n}_{j-1} - L^{n+1}_{j} - L^{n}_{j}\right) - D^{n+\frac{1}{2}}_{j-\frac{1}{2}} \,. \tag{18}$$

In this implicit form the variables to be simultaneously determined are now L^{n+1}_{j} and L^{n+1}_{j-1} in addition to $E^{n+1}_{j-\frac{1}{2}}$ and $P^{n+1}_{j-\frac{1}{2}}$. But these energy equation variables are no longer independent of other mass points as they were before, and it is now necessary to solve all of the energy (and equation of state and opacity) equations for all of the mass points simultaneously to arrive at new values. Although such a simultaneous "relaxation" of these equations avoids the restriction of an explicit stability limitation on the time step size permissible, it does add considerable computational complication and redundant numerical exercise to the problem, and so can increase the running time per time step several fold - in part negating the freedom to choose larger time intervals. The procedure consists of the evaluation of a set of forward-backward substitution coefficients, related to the proximity of variables to their proper values in a self consistent set of solutions, i.e., related to a measure of the relaxation in a

given time step.* In this process, the basic variables are taken as temperature (T) and luminosity (L).

Beginning with j = 1, the following quantities are computed:

$$\sum_{j-\frac{1}{2}}^{n+1} \equiv 2\Delta m_{j-\frac{1}{2}} \Big[E^{n}_{j-\frac{1}{2}} - E^{n+1}_{j-\frac{1}{2}} \tag{19}$$

$$+ \Big(\frac{P^{n+1}_{j-\frac{1}{2}} + P^{n}_{j-\frac{1}{2}}}{2} + Q^{n+\frac{1}{2}}_{j-\frac{1}{2}}\Big) \cdot \big(V^{n}_{j-\frac{1}{2}} - V^{n+1}_{j-\frac{1}{2}}\big) - D^{n+\frac{1}{2}}_{j-\frac{1}{2}}\Big] ,$$

$$C^{n+1}_{j-\frac{1}{2}} \equiv 2\Delta m_{j-\frac{1}{2}} \Big[\frac{\partial E^{n+1}_{j-\frac{1}{2}}}{\partial T^{n+1}_{j-\frac{1}{2}}} + \frac{\partial P^{n+1}_{j-\frac{1}{2}}}{\partial T^{n+1}_{j-\frac{1}{2}}} \Big(\frac{V^{n+1}_{j-\frac{1}{2}} - V^{n}_{j-\frac{1}{2}}}{2}\Big)\Big] , \tag{20}$$

$$\frac{\partial E^{n}}{\partial T^{n}} \equiv \frac{E(T^{n},V^{n}) - E^{n}[T^{n}(1+\epsilon),V^{n}]}{\epsilon T^{n}} \text{, where typically } \epsilon \lesssim 10^{-4} \tag{21}$$

$$H^{n+1}_{j-\frac{1}{2}} \equiv C^{n+1}_{j-\frac{1}{2}} + \Delta t^{n+\frac{1}{2}} G^{n+1}_{j-1} , \tag{22}$$

$$K^{n+1}_{j-\frac{1}{2}} \equiv \Big[\sum_{j-\frac{1}{2}}^{n+1} + \Delta t^{n+\frac{1}{2}} \big(L^{n+1}_{j-1} + L^{n}_{j-1} - L^{n+1}_{j} - L^{n}_{j}\big)\Big] + \Delta t^{n+\frac{1}{2}} J^{n+1}_{j-1} , \tag{23}$$

in which $J^{n+1}_{o} = G^{n+1}_{o} = 0$ (for spherical or cylindrical symmetry);

---

*This particular forward-backward substitution scheme, coupled with a Newton's method for projecting new values, was suggested by R.E. LeLevier and has been used successfully in earlier similar programs.

$$\sigma_j^{n+1} \equiv (R_j^{n+1})^{2(\delta-1)} \left[(T_{j-\frac{1}{2}}^{n+1})^4 - (T_{j+\frac{1}{2}}^{n+1})^4 \right] - (k\Delta m)_j^{n+1} L_j^{n+1} , \qquad (24)$$

$$a_{j+\frac{1}{2}}^{n+1} \equiv 4(R_j^{n+1})^{2(\delta-1)} (T_{j+\frac{1}{2}}^{n+1})^3 + L_j^{n+1} \frac{\partial (k\Delta m)_j^{n+1}}{\partial T_{j+\frac{1}{2}}^{n+1}} , \qquad (25)$$

$$b_{j-\frac{1}{2}}^{n+1} \equiv 4(R_j^{n+1})^{2(\delta-1)} (T_{j-\frac{1}{2}}^{n+1})^3 - L_j^{n+1} \frac{\partial (k\Delta m)_j^{n+1}}{\partial T_{j-\frac{1}{2}}^{n+1}} , \qquad (26)$$

$$G_j^{n+1} \equiv \frac{a_{j+\frac{1}{2}}^{n+1} H_{j-\frac{1}{2}}^{n+1}}{(k\Delta m)_j^{n+1} H_{j-\frac{1}{2}}^{n+1} + \Delta t^{n+\frac{1}{2}} b_{j-\frac{1}{2}}^{n+1}} , \qquad (27)$$

$$J_j^{n+1} \equiv \frac{H_{j-\frac{1}{2}}^{n+1} \sigma_j^{n+1} + b_{j-\frac{1}{2}}^{n+1} K_{j-\frac{1}{2}}^{n+1}}{(k\Delta m)_j^{n+1} H_{j-\frac{1}{2}}^{n+1} + \Delta t^{n+\frac{1}{2}} b_{j-\frac{1}{2}}^{n+1}} . \qquad (28)$$

These coefficients are successively evaluated for each increasing integer value of j (at each mass point) until the next j is at a point beyond the sensible diffusion front where temperature changes from ambient are negligible. This zone is designated as the turn-around point (j^*) where conditions are such that $T^n_{j^*-\frac{1}{2}} > Z_1$ but $T^n_{j^*+\frac{1}{2}} < Z_1$. When there is no temperature gradient, the luminosity must be zero, so that $L_{j^*+1} \approx 0$, providing $T_{j+\frac{1}{2}} < Z_1$ for all $j > j^*$, Z_1 being small.

The procedure then is to compute changes in temperature and luminosity (using the foregoing coefficients) beginning at j* and working back to $j = 0$.

The temperature at $j^* + \frac{1}{2}$ on the $(i + 1)$st iteration is first calculated as

$$ {}^{i+1}T^{n+1}_{j^*+\frac{1}{2}} = {}^{i}T^{n+1}_{j^*+\frac{1}{2}} + \delta T_{j^*+\frac{1}{2}} , \tag{29} $$

where

$$ \delta T_{j^*+\frac{1}{2}} = K^{n+1}_{j^*+\frac{1}{2}} \Big/ H^{n+1}_{j^*+\frac{1}{2}} . \tag{30} $$

Then beginning with $j = j^*$, successive evaluations go as

$$ \delta L_j = - G^{n+1}_j \, \delta T_{j+\frac{1}{2}} + J^{n+1}_j , \tag{31} $$

$$ {}^{i+1}L^{n+1}_j = {}^{i}L^{n+1}_j + \delta L_j , \tag{32} $$

$$ \delta T_{j-\frac{1}{2}} = (-\Delta t^{n+\frac{1}{2}} \, \delta L_j + K^{n+1}_{j-\frac{1}{2}})/H^{n+1}_{j-\frac{1}{2}} , \tag{33} $$

reducing j each time until $j = 1$. "Relaxation" or convergence is determined by testing each $\delta T/T$ or $\delta L/L$ against an arbitrary small constant and entering another iteration loop to recompute the coefficients and another set of δT and δL as long as any one δT or δL exceeds the chosen test constant.

ADDED MASS

Since interests in explosion problems encompass phenomena occuring both very close to the explosive (in a small mass and volume) and very far from the source (with very large masses and volumes of air

intervening), it is frequently convenient to bring in more air mass during the calculation.

To expand the mass system without adding indefinitely to the number of mass points carried requires some mechanism for dropping or rather combining interior masses as new masses are added at a front. When zones are combined, special care should be taken to conserve energy, momentum and mass. In this program, one zone at a time (as needed) is added, and two zones elsewhere (in the interior) are combined in order to keep constant the number of zones carried in the calculation. Because of the form of the artificial viscosity, sudden discontinuities in mass element size can create spurious signals as shocks cross them. For this reason, some care must be exercised in deciding when and where zones may be combined. Generally, zones are selected to be combined where motions and pressure or temperature gradients are least, i.e., in such a way as to retain essential problem detail while not unduly restricting the size of time steps dictated by stability requirements.

SOURCES, SINKS, AND DEPLETION

The single variable, D, appearing in the energy equations can be used to represent such physical features as can be expressed as energy losses or sources. Such source or sink energy rates may be included in some or all zones in the problem and may vary with time. The detonation of high explosive can be modeled by choosing this source term to represent the rate at which energy is released in detonations. With a finite spread to the detonation front, this source term becomes the product of the energy generated per unit mass of explosive (E_{CJ}), the detonation velocity (U_{CJ}), and the time increment ($\Delta t^{n+\frac{1}{2}}$), divided by the total spread of the detonation front appropriate to that dictated by the artificial viscosity, i.e.,

$$D^{n+\frac{1}{2}}_{j-\frac{1}{2}} = \frac{-E_{CJ}\, U_{CJ}\, \Delta t^{n+\frac{1}{2}}}{S\, \Delta R_{j-\frac{1}{2}}}, \tag{34}$$

where S is the number of zones of detonation front spread. Such a rate of energy increase would then be maintained in each zone until the total energy added equals the desired detonation energy, i.e., for a time equal to $S\Delta R/U_{CJ}$.

STABILITY REQUIREMENTS

Such finite difference methods as employed here are frequently subject to mathematical limitations which place upper bounds on the size of time increments that can be taken without the unstable growth of spurious signals from truncation or round-off error. The usual Courant Condition is simply a statement that time steps should be smaller than the time for a sound signal to propagate beyond the boundaries of adjacent zones (as in Fig. 2). Thus, $\Delta t < \Delta R/s$ for every zone, or $\Delta t < [\Delta R_{j-\frac{1}{2}}/s_{j-\frac{1}{2}}]_{min}$, in which s is the local sound speed. It is generally time consuming to calculate the sound speed at each zone when an approximate form which is quicker to compute will suffice to determine the maximum allowable time step within a reasonable accuracy. For an ideal gas, the sound speed squared is given by

$$s^2 = \gamma P/\rho = \gamma PV, \qquad (35)$$

and the stability condition can be expressed as

$$\Delta t^2 \lesssim V(\Delta m)^2/C_3 P\, R^{2(\delta-1)}, \qquad (36)$$

in which we have substituted $\Delta R = V\,\Delta m/R^{(\delta-1)}$ and C_3 is the maximum value of γ to be encountered and depends on the materials used and their equations of state. For ideal gases, a value of 5/3 is a maximum, and lesser values are larger than unity always, so that using 5/3 for C_3 could keep Δt smaller than necessary by no more than 23%. For the dense gases of detonation products before expansion, or for fluids such as water, or for solids at high temperatures and densities the effective maximum γ can exceed 5/3, and the constant C_3 should be chosen with that in mind.

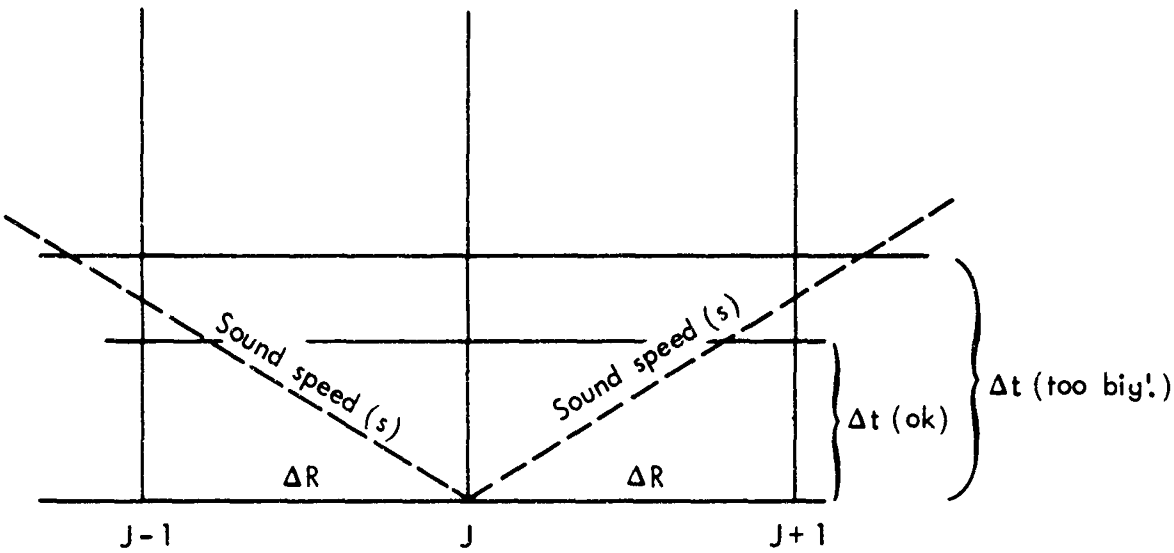


Fig.2—Courant stability condition

In shock fronts or compression regions, the presence of a quadratic artificial viscosity changes the nature of the linearized differential equations from one which characterizes a wave equation to one of a diffusion type. Consequently, in such shock regions another difference equation stability condition exists, a diffusion stability limit. An approximate derivation of the viscosity stability condition comes from the momentum conservation equation (Eq. 2), with the assumption that the artificial viscosity pressure (Q) dominates the usual thermodynamic pressure (P). In that case,

$$\frac{\partial u}{\partial t} \simeq - R^{\delta-1} \frac{\partial Q}{\partial m} . \tag{37}$$

In regions of compression, the quadratic form of the artificial viscosity has been taken as

$$Q = \frac{C_1 (\Delta m)^2}{V\, R^{2(\delta-1)}} \left(\frac{\partial V}{\partial t}\right)^2 . \tag{38}$$

But differentiating the conservation of mass equation (Eq. 1), and substituting for $\partial V/\partial t$ leads to

$$Q = \frac{C_1 (\Delta m)^2}{V\, R^{2(\delta-1)}} \left(\frac{\partial R^{\delta-1} u}{\partial m}\right)^2 . \tag{39}$$

With this form and from

$$\frac{V}{R^{\delta-1}} = \frac{\partial R}{\partial m} , \tag{40}$$

the momentum equation in a shock (Eq. 37) becomes approximately

$$\frac{\partial u}{\partial t} \simeq - C_1 (\Delta m)^2 V \frac{\partial}{\partial R} \left[\frac{V}{R^{2(\delta-1)}} \left(\frac{\partial u}{\partial R}\right)^2\right] , \tag{41}$$

and ignoring geometric divergence terms which occur in cylindrical or spherical symmetry (valid as long as shock front dimensions are small compared to radii or other problem dimensions) this equality becomes

$$\frac{\partial u}{\partial t} \simeq -\frac{C_1(\Delta m)^2 V^2}{R^{2(\delta-1)}} \frac{\partial}{\partial R}\left(\frac{\partial u}{\partial R}\right)^2$$

$$\simeq -\frac{2C_1(\Delta m)^2 V^2}{R^{2(\delta-1)}} \frac{\partial u}{\partial R} \frac{\partial^2 u}{\partial R^2} \quad . \tag{42}$$

In shock regions, derivatives such as $\partial u/\partial t$ or $\partial^2 u/\partial R^2$ are large; i.e., rapid velocity changes and velocity gradient changes are taking place relative to changes in other parameters, so that to some approximation this equation appears as a diffusion form

$$\frac{\partial u}{\partial t} \simeq K \frac{\partial^2 u}{\partial R^2} ,$$

where (43)

$$K \equiv \frac{2C_1(\Delta m)^2 V^2}{R^{2(\delta-1)}} \left|\frac{\partial u}{\partial R}\right| , \ (\text{for } \frac{\partial u}{\partial R} < 0) ,$$

which is considered nearly constant or slowly varying in the region of interest. Since we have not chosen to define the artificial viscosity at the midpoint between the new and the old velocity, but rather have defined it at the old velocity time ($n-\frac{1}{2}$), this diffusion differential form (Eq. 43) translates into a corresponding difference equation which uses velocities at adjacent mass points and at the <u>old</u> time ($n-\frac{1}{2}$) to extrapolate to a new velocity at time $n+\frac{1}{2}$

$$u_j^{n+\frac{1}{2}} \simeq u_j^{n-\frac{1}{2}} - K \frac{\Delta t^n}{(\Delta R_j^n)^2}\left(u_{j+1}^{n-\frac{1}{2}} - 2u_j^{n-\frac{1}{2}} + u_{j-1}^{n-\frac{1}{2}}\right) \quad . \tag{44}$$

By considering the growth of perturbations in the new velocity (see Von Neumann and Richtmyer, Ref. 1, p. 236), it becomes clear that stability for such a forward-difference scheme has an explicit stability condition which is

$$\Delta t \le \frac{(\Delta R)^2}{2K} = \left.\frac{(\Delta R)^2 R^{2(\delta-1)}}{4C_1 (\Delta m)^2 V^2 \frac{\partial u}{\partial R}}\right]_{min} ,$$

or (45)

$$\left(4C_1 \frac{\partial u}{\partial R}\right)\Big]_{max} \Delta t \le 1 .$$

But, again ignoring geometric divergence terms,

$$\frac{\partial u}{\partial R} = \frac{R^{\delta-1}}{V}\frac{\partial u}{\partial m} = \frac{R^{\delta-1}}{V}\left[\frac{1}{R^{\delta-1}}\frac{\partial V}{\partial t} - \frac{(\delta-1)u}{R}\right] \simeq \frac{1}{V}\frac{\partial V}{\partial t} \simeq \frac{V^{n+1}-V^n}{V^{n+\frac{1}{2}}\Delta t^{n+\frac{1}{2}}} , \qquad (46)$$

so that

$$\left.\frac{4C_1\left(V^{n+1}_{j-\frac{1}{2}} - V^{n}_{j-\frac{1}{2}}\right)}{V^{n+\frac{1}{2}}_{j-\frac{1}{2}}}\right]_{max} \le 1 . \qquad (47)$$

When the explicit form is used to compute radiation diffusion, a similar forward-difference stability condition applies, viz,

$$\Delta t < \left.\frac{\Delta m^2}{2C''}\right)_{min} = \left.\frac{(k\Delta m)\left(\frac{\partial E}{\partial T}\right)\Delta m}{8T^3 R^{2(\delta-1)}}\right]_{min} . \qquad (48)$$

Since for various regions and various reasons the implicit radiation diffusion routines are unable to converge on a realistic solution and are for practical purposes unstable beyond some reasonably small time steps, it is often necessary to arbitrarily limit the size of time steps to a value larger than but proportional to that allowed for explicit radiation. To make such a choice convenient, the program includes an explicit stability condition with a constant (C_5) which can be chosen as suitable for implicit radiation (e.g., equal to 2,3, or 4), but must be taken as unity for the explicit routines.

These three stability conditions are:

Courant:

$$\Omega^n \equiv \left[\frac{(\Delta t^{n+\frac{1}{2}})^2 (R_j^n)^{2(\delta-1)} P^n_{j-\frac{1}{2}} C_3}{V^n_{j-\frac{1}{2}} (\Delta m_{j-\frac{1}{2}})^2}\right]_{max} \leq 1 . \qquad (49)$$

Shock (artificial viscosity):

$$\Lambda^n \equiv \left[\frac{C_4 (V^{n-1}_{j-\frac{1}{2}} - V^n_{j-\frac{1}{2}})}{V^n_{j-\frac{1}{2}}}\right]_{max} \left(\frac{\Delta t^{n+\frac{1}{2}}}{\Delta t^{n-\frac{1}{2}}}\right) \leq 1 , \qquad (50)$$

in which $C_4 \leq 4C_1$.

Radiation diffusion;

$$\Gamma^n \equiv \left[\frac{8(R_j^n)^{2(\delta-1)} (T_j^n)^3}{C_5 \Delta m_j (k\Delta m)_j^n \left(\frac{\partial E}{\partial T}\right)_j}\right]_{max} \Delta t^{n+\frac{1}{2}} \leq 1 . \qquad (51)$$

$C_5 = 1$ for explicit radiation.

$C_5 \geq 1$ for implicit (open choice).

III. HYDRODYNAMIC EXAMPLE

A simple test problem will facilitate the explanation of the essential features of this program. In any such code there are many arbitrary designations and notations which are easier demonstrated than explained. Hopefully, none of the empirical choices have significant influence on the results of any calculations in so far as the physical representation is concerned. Some of the parameters, such as choice of the number of zones or mass points, choice of zone sizes, or choices of convergence test criteria do affect the results when a choice becomes extreme or so coarse as to reduce accuracy. A few example calculations may help demonstrate both appropriate values for such constants as are required and the need or function of each input required.

As a simplest beginning, a plane shock wave generated by a constant pressure at one boundary will be demonstrated. Such a problem has a simple analytical solution, and the deviations from the correct solution that occur when we make various choices of parameters are easily identified. When the constant pressure is applied at the left-hand boundary of a volume of ideal gas, a shock of constant strength should move at constant speed to the right. The usual Hugoniot or shock conservation conditions relate the conditions behind a plane shock to those in front of it as follows:

$$\frac{u_s}{U} = 1 - \frac{\rho_o}{\rho_s} \quad \text{or} \quad \rho_o U = \rho_s (U - u_s) , \quad \text{(mass)} \ldots \qquad (52)$$

$$E_s - E_o = \frac{P_s + P_o}{2} \left(\frac{1}{\rho_o} - \frac{1}{\rho_s}\right) , \quad \text{(energy)} \ldots \qquad (53)$$

$$P_s - P_o = \rho_o \, u_s \, U , \quad \text{(momentum)} \ldots \qquad (54)$$

in which subscripts "s" refer to shock quantities, subscripts "o" refer to ambient (pre-shock) values, U is the shock velocity, u the particle velocity, ρ the density, P the pressure, and E the internal energy. It has further been assumed that the pre-shock gas velocity is zero.

If one defines an "effective gamma" by the relation $E = P/\rho(\gamma-1)$, i.e., $\gamma \equiv 1 + P/E\rho$, and eliminates internal energies from these Hugoniot expressions, then in place of the energy equation, one can write

$$\frac{\rho_s}{\rho_o} = \frac{\left(\frac{P_s}{P_o}\right)\left(\frac{\gamma_s + 1}{\gamma_s - 1}\right) + 1}{\frac{P_s}{P_o} + \left(\frac{\gamma_o + 1}{\gamma_o - 1}\right)} . \tag{55}$$

Eliminating the shock velocity (U) from Eqs. (52) and (54), leads to an expression for the square of the peak particle velocity (u_s) in terms of density and pressure,

$$u_s^2 = \frac{(P_s - P_o)}{\rho_o}\left(1 - \frac{\rho_o}{\rho_s}\right) , \qquad \ldots \tag{56}$$

and using Eq. (55) to eliminate density leads to

$$u_s^2 = \frac{2(P_s - P_o)}{\rho_o} \frac{\left[\frac{P_s}{P_o}\left(\frac{1}{\gamma_s - 1}\right) - \frac{1}{\gamma_o - 1}\right]}{\left[\frac{P_s}{P_o}\left(\frac{\gamma_s + 1}{\gamma_s - 1}\right) + 1\right]} . \tag{57}$$

For an ideal gas ($\gamma_s = \gamma_o$), this expression reduces to

$$u_s^2 = \frac{2(P_s - P_o)^2}{[(\gamma+1)P_s + (\gamma-1)P_o]\rho_o} . \tag{58}$$

Similarly, the square of the shock velocity becomes

$$U^2 = \frac{(\gamma+1)P_s+(\gamma-1)P_o}{2\rho_o} . \quad \ldots \quad (59)$$

With a value of γ equal to 7/5 (corresponding to an ideal diatomic molecule gas and appropriate for air at normal temperatures) these expressions reduce to the following:

$$U = \sqrt{\frac{6P_s+P_o}{5\rho_o}} , \quad \ldots \quad (60)$$

$$u_s = \frac{(P_s-P_o)}{\sqrt{\rho_o(6P_s+P_o)/5}} , \quad \ldots \quad (61)$$

and the density ratio becomes

$$\frac{\rho_s}{\rho_o} = \frac{6P_s+P_o}{P_s+6P_o} . \quad \ldots \quad (62)$$

The specific example used to illustrate the mechanics of running a hydrodynamics shock problem employs a suddenly applied, steady pressure at the left-hand boundary, and that pressure was chosen as one kilobar, or 10^9 dynes/cm^2. The ambient pressure into which the disturbance propagates is taken as that corresponding to an ambient density of 0.0011 gm/cm^3 and a temperature of 293^{o}K in an ideal diatomic gas (γ = 1.4, R $\simeq$ 2.8777 x 10^{+6} dyne-cm/gm/^{o}K) the caloric equation of state becomes

$$P = (\gamma-1)\rho E = 0.4\rho E , \quad \ldots \quad (63)$$

and the thermal equation of state becomes

$$T = \frac{P}{\rho R} = \left(\frac{\gamma-1}{R}\right) E = 1.39 \times 10^{-7}E, \quad \ldots \quad (64)$$

with T in ^{o}K and E in ergs/gm, P in dyne/cm^2 and ρ in gm/cm^3.

The value of the ambient pressure is approximately 0.927482 bars. The pre-shock energy is about 2.10791×10^9 ergs/gm. Thus, from the above relations (Eqs. 60-64) and the above pre-shock values and for a driving pressure of 10^9 dynes/cm^2, the pre- and post-shock values can be computed and used to check the performance of the numerical program. These values are listed in Table 1 below.

Table 1

SHOCK PARAMETERS FOR EXAMPLE CALCULATION

Symbol	Hydrodynamic Parameter	Pre-Shock	Post-Shock
P	Pressure(dyne/cm^2)	0.927482×10^6	10^9
ρ	Density(gm/cm^3)	1.1×10^{-3}	6.56173×10^{-3}
u	Particle velocity (cm/sec)	0	869,452
U	Shock velocity (cm/sec)	—	1,044,552
E	Energy(erg/gm)	2.10791×10^9	3.80999×10^{11}
T	Temperature($^\circ$K)	293.00	52,959

In this demonstration problem we have arbitrarily chosen thirty zones of one centimeter thickness into which the disturbance (shock) may propagate. The initial conditions in these zones, as well as in any zones to be added later, are the pre-shock conditions listed above.

The initial time step may be taken as anything less than that which the stability conditions stipulate, but too small an initial step may require many cycles to build up to a significant increment since the program limits increases in $\Delta t^{n+\frac{1}{2}}$ to $(9/8)\Delta t^{n-\frac{1}{2}}$. In cases of a suddenly applied load or an initially rapidly moving boundary, the stability conditions may not provide a correct limit on the first cycle. In any case, such failure is avoidable by insuring that the initial step is chosen as less than the time for a boundary to move across the next zone, and/or less than the time for a sound signal to cross that zone.

The acceleration of the left hand boundary on the first cycle is approximately

$$\frac{\delta u}{\Delta t} \simeq \frac{P_{-\frac{1}{2}} - P_{\frac{1}{2}}}{\Delta m_o} , \tag{65}$$

in which $\Delta m_j \equiv (\Delta m_{j+\frac{1}{2}} + \Delta m_{j-\frac{1}{2}})/2$ and $\Delta m_{-\frac{1}{2}} = 0$. The pressure, $P_{-\frac{1}{2}}$ is the boundary pressure of 10^9 dyne/cm^2, $P_{\frac{1}{2}}$ is the ambient pressure ($\sim 10^6$ dyne/cm^2), and a $\Delta m_{j+\frac{1}{2}} = \rho_{j+\frac{1}{2}} \Delta R_{j+\frac{1}{2}} = 1.1\text{x}10^{-3}$ gm/cm^2. Thus the velocity of the left boundary after the first time step is

$$u_o^{\frac{1}{2}} = \Delta t^o \frac{(P^o_{-\frac{1}{2}} - P^o_{\frac{1}{2}})}{\Delta m_o} \simeq \Delta t^o\ 1.818\text{x}10^{12} (\text{cm/sec}) . \tag{66}$$

The time increment Δt^o may be interpreted as an average between the $\Delta t^{-\frac{1}{2}}$ and $\Delta t^{\frac{1}{2}}$. If we presume $\Delta t^{-\frac{1}{2}} = 0$, then $\Delta t^o = \Delta t^{\frac{1}{2}}/2$, i.e., half the initial time step. Thus

$$u_o^{\frac{1}{2}} \simeq 0.9091\text{x}10^{12}\ \Delta t^{\frac{1}{2}}\ (\text{cm/sec}) , \tag{67}$$

and the change in position of the boundary becomes

$$\delta R = u_o^{\frac{1}{2}} \Delta t^{\frac{1}{2}} \simeq 0.9091\text{x}10^{12}\ (\Delta t^{\frac{1}{2}})^2\ (\text{cm}) . \tag{68}$$

If we ask that the initial change in the left-hand boundary be small compared to the zone size, say less than 10% of the first zone thickness, then

$$\Delta t^{\frac{1}{2}} < \sqrt{\frac{\Delta R}{0.9091\text{x}10^{13}}} \simeq 0.33166\text{x}10^{-6} \sqrt{\Delta R}\,. \tag{69}$$

We are, then, led to an initial choice of time step of less than $0.33\text{x}10^{-6}$ sec. In this first example we have (arbitrarily) chosen to start with $\Delta t^{\frac{1}{2}} = 2\text{x}10^{-7}$ sec, or, in the program units of milliseconds, $\Delta t^{\frac{1}{2}} = 2\text{x}10^{-4}$ msec and $\Delta t^{0} = \Delta t^{\frac{1}{2}}/2 = 10^{-4}$ msec.

INTERPRETATION OF EXAMPLE PROBLEM NO. 1 OUTPUT

HAROLD TEST 1.* The problem is so labeled for Hydrodynamic And Radiation, One Lagrangian Dimension, and is preferred by some of us, as within the six letter limitation on notation. The senior author would prefer the short title RODHARD, standing for RAND One Dimensional Hydrodynamic And Radiation Diffusion, which is somewhat more descriptive.

IDEAL GAS. A further identification of the nature of the problem.

EQUATIONS OF STATE FOR THE GENERATOR. These equations of state are listed as a matter of record, since questions may otherwise arise at later times as to just what fits or tables were used. In this case, the Generator was provided with the two relations

$$P = (\gamma-1)E\rho \quad \text{as} \quad \text{FP1001} = .4\text{*E/V}, \tag{70}$$

and

$$T = (\gamma-1)E/R \quad \text{as} \quad \text{FE1001} = .139\text{*E}. \tag{71}$$

The Executor was given the single equation

$$P = .4\text{*E/V}, \tag{72}$$

*Expressions in CAPITAL LETTERS or underscored are those appearing on the output sheets reproduced at the end of this section and to be explained or discussed here.

with the additional provision for temperature calculation at output times as specified in the Generator. For hydrodynamics, the temperature is not a sufficient nor a necessary quantity.

HISTORIES. To restart or continue the problem without beginning over again, tape histories can be provided periodically, storing data analogous to that necessary at the beginning and provided by the Generate subroutines. The selection of when such a tape record shall be written can be either by cycle intervals or by problem time intervals. Six successive rates may be specified. In this example, histories are called for every .025 milliseconds until 1 millisecond.

PRINTOUTS. The frequency at which specified listings of variables at all active mass zones will be listed can be similarly specified. In this case, we have elected to print out such data on the first three cycles to aid code checking. Subsequent listings of data are called for at cycle 10, at forty cycle intervals until cycle 263, at cycles 263 and 264 (to illustrate the variables just before and just after the combining of a pair of masses to accomodate an added zone), and at fifty cycle intervals thereafter until cycle 614.

ENERGY CHECKS. In many problems it is helpful to keep track of both the distribution of a net explosion energy and the total net energy, and this is provided in a print of the internal, kinetic and total energy in each region, as well as the sum of internal, kinetic and total energies over all the regions. In this example, since work is being done continuously by the pressure on the boundary, such an energy summation serves little purpose and little check on the accuracy of the calculation. Consequently, we have hoped to avoid any energy checks by selecting an interval larger than the expected length of the run (i.e., every 1000 cycles).

PMIN BNDRY COND. Whenever a special boundary condition is selected, it will be listed here. In this example, a constant pressure of 0.1 jerks*/meter^3 (1 kilobar) is applied at the lower (or left-hand) boundary - at $j= -\frac{1}{2}$ - for a very long time (for 10^{11} milliseconds).

RMIN = 1. This indication of the initial value of the position of the left-hand boundary is important in that it indicates a nonzero value of the position. Whenever the RMIN is started at exactly

*A jerk $\equiv 10^{16}$ ergs.

zero value, the program avoids calculation of the velocity and the radius at that boundary, and consequently, the boundary remains at zero value throughout the problem. Such is the intention for spherical and cylindrical geometries, and could be the case where a rigid boundary is desired at the left of a plane geometry problem. In this case, both the velocity and the position at j=0 will be computed each cycle, and can be expected to change.

PLANE GEOMETRY. This is a reminder of the selected geometrical factor - that the problem is set up in plane rather than cylindrical or spherical symmetry.

REGION 1. MATERIAL 1001. Each region beginning at the left-hand boundary is designated with an increasing integer (region 1 being the first, region 2, next, etc.) and by a material number designation. The material number should correspond to one of those listed with the equations of state, and thereby identifies the material properties that will be ascribed to that region. Also listed for each region are the various selectable constants, C_1 through C_5. The definition of C_1 and C_2 is given in Eq. 13 or as the amplitudes selected for the quadratic and the linear terms of the artificial viscosity, respectively. Since the shock in this example will be a fairly strong one, no linear viscosity is necessary, and C_2 is set equal to zero. C_1 is chosen equal to 6. The number of zones to be expected in the shock front, as derived in a similar manner by von Neumann and Richtmyer[1] becomes

$$\text{Number of zones} \cong \pi\sqrt{2C_1/(\gamma+1)} \quad . \tag{73}$$

Since this example problem uses an ideal gas with $\gamma = 1.4$, a value of 6 for C_1 should build a shock spread of about 7 zones. If we were in water and so using a γ more nearly equal to 7, then a value of C_1 = 14 or 15 would be necessary to make a spread of six zones.

The Courant stability condition also includes an adjustable constant. As used in Eq. (36), C_3 represents a maximum value of γ, so in this case it can be taken as 1.4. It was in fact, taken as slightly larger, as 1.6, but that is not necessary.

The artificial viscosity stability condition involves a constant C4 which should be at least as large as four times C_1 (see Eqs. 47 and 50). Demonstrating a certain insensitivity in this condition, we have used without unstable results a value of only 16, while $4C_1 = 24$.

The radiation stability constant, C_5 (as defined in Section II) must be set to unity for explicit radiation diffusion. Larger values of C_5 are theoretically permissible for the implicit radiation formulation. For hydrodynamics, it is immaterial, and in this example, is set to zero.

The ambient energy for each region is also specified so that in totaling the energy of that region and/or of the whole system, the net energy introduced by a source (an explosive yield, or an influx of radiation energy) can be identified and maintained even as new zones (at ambient conditions) are added to the region. Since a continuous influx of energy is involved in this example problem, no attempt to account for the net energy will be made, and E = 0 will suffice. If one were to choose to include (or rather exclude) this ambient energy in the energy check sums, the appropriate value would be 0.2108, the same energy listed as initial value for the internal energy of the last zone.

The table of initial values which follows the list of constants specifies in the units of the code (the meter, millisecond, megagram system) for each zone the radius "R" (meters), particle velocity "U" (meters/millisecond), temperature "TEM" (10^{4} °K), specific volume "VL" (m^3/megagram or cm^3/gm), pressure "PR" (jerks/m^3 = 10^{10} dynes/cm^2), and internal energy "EG" (jerks/megagram = 10^{10} ergs/gm). A vestige of code checking interests are the next two columns labeled "KP" and "KM". These are, respectively, the opacities at zone boundaries, using the density and the material designation (and so the opacity prescription) of the zone just ahead of the zone boundary $KP \equiv K_j(T_j, V_{j+\frac{1}{2}})$ and just behind the boundary $KM \equiv K_j(T_j, V_{j-\frac{1}{2}})$. Since this example does not include radiation, opacities are of no interest and have been left zero, as have luminosities in the last column labelled "EL".

The mass increments or elements are listed as "DMASS" in the next to the last column of the initial values table. The first column shows a spacing between zones of one centimeter (0.01 m) and the specific volume of 909.1 cm^3/gm corresponds to a density of $1.1x10^{-3}$ gm/cm^3 so that the mass elements, which in plane geometry are just the product of the zone dimension times the density, become $1.1x10^{-5}$.

Listed below the table of initial values are such factors as the initial time increments and others which have some arbitrariness of choice and so should be selected at the outset. The time increments during the problem running can be controlled automatically by the stability conditions, but the initial values must be chosen specifically. In this case, DT stands for the average of the current and just previous time increment (Δt^n) and is taken as half the current choice as if the previous value were zero. As discussed earlier, the value of the initial time step (DTP) has been chosen as $\Delta t^{n+\frac{1}{2}} = 2x10^{-4}$ msec.

If the problem involves the ingestion of mass or of new zones as it progresses, then some information must be supplied as to where zones are to be doubled and what size zones are to be added. Under MASS ADD INFO, J0 = 5 indicates that we have chosen to combine the fifth and sixth zones when new zones are needed (and then sequentially the next two zones, etc.). By JOS = 0 and JOM = 23 we have specified that when J0 has advanced to j = 23 it is to be set back to j = 0. The size of the added zones is given by DR. When DR is positive, it indicates directly the thickness of the added zone, such that in plane geometry $\Delta m = \rho \Delta R$, where ρ is the density of the last zone (at j=JMAX). When DR is given as a negative number, it indicates a fractional increment, as a fraction of the previous radius or the last position value (R_{jmax}), so that for this example, the first added zone will have a thickness $\Delta R = DR \cdot R_{30} = 0.0076923x1.3 = 0.01$ m.

The set of X's listed under PERCENTS are not percentages but are fractional numbers used in tests of the smallness of the change in computed quantities relative to the initial or final value of

that quantity. X1, X2, and X3 are associated with convergence routines in the radiation diffusion by implicit method, and are set to zero in this strictly hydrodynamic example. X4 = 0.4×10^{-5} indicates that a variable being determined in GETVAR has been found to be consistent with the determining values through the equation of state to a fractional accuracy of at least 4 parts in a million.

In problems where zones are added and combined automatically many times, there is the possibility of choosing J0, JOS, and JOM such that some region of the problem becomes too coarsely zoned. A check or control on the maximum size to which any one zone can grow is provided in the use of X5 since, before two zones are combined, their combined width is compared with X5 times the largest dimension or radius in the problem. In this case, the selection of X5 = 0.125 guarantees that no zone can become larger than one eighth of the largest radius. The last fraction, X6, is the convergence test for energy compatibility (in the energy conservation equation of the ROA routine) with pressure. Thus on successive evaluations, the internal energy shows a change of less than one part in ten thousand (for the value of X6 = 0.1×10^{-3}).

In this example, as often is the case, most of the zones in the problem are inactive initially, and need not be computed until some signal propagates into them. Since it is wasteful to compute through them, a floating boundary condition is set up which determines which will be the last zone to be calculated on each cycle. That last zone is denoted as "JHAT", which in this problem is started at 3. To advance JHAT when needed, a test is made on the temperature (if subroutine JHTT is used) or the particle velocity (if subroutine JHTU is used) at that last zone (j = JHAT) against a constant Z2. Whenever the temperature (or velocity) equals or exceeds Z2, JHAT is increased by unity, and one more zone is computed. In this example, we have chosen to test on velocity (using subroutine JHTU), and Z2 has been taken to be 10^{-4}.

The desired number of active zones is limited by the constant JL, such that whenever JHAT reaches JL, either another zone must be added while two other zones are combined (thus keeping JL constant), or a special boundary condition is applied, such as a free or fixed boundary.

The constant Z1 is similar to Z2 in that it determines the threshold temperature for adding another zone to the radiation diffusion part of a calculation. Since this example has no radiation flow, Z1 has been set to zero, but could have any value. Similarly, JSTAR, which denotes the last zone for radiation diffusion, has been chosen zero, but is of no consequence to this calculation.

The last cycle to be computed is denoted as NF, and is here chosen as 614.

A list of the subroutines used in the Executor follows the Generate input and starting data print-out.

The print-out for the actual execution of the problem begins with a title (TEST 1. HYDRO ONLY. IDEAL GAS), and then follows a list of the initial values of the selected variables displayed in the format chosen for those zones of index J $\leq$ JHAT + 3. The units chosen for this test problem are the internal calculation units. The particular parameters chosen for output, and the order of output from left to right is zone number (j), radius, particle velocity, density, temperature, internal energy, pressure, artificial viscosity, and mass per zone. The artificial viscosity is a convenient indicator of compressions or shocks. The masses are constants of the motion in this Lagrangian system, but with the later periodic combining and adding of zones, its listing simplifies monitoring of zoning and makes any disparities in adjacent mass increments more readily identifiable.

Following the initial value listing is a line of information for the first cycle, a type of output which is presented for every cycle. Listed from left to right <u>in the internal units of the program</u> are the cycle number (n), the time at the end of the n-th cycle (milliseconds), the time increment for that cycle ($\Delta t^{n-\frac{1}{2}}$), LAMBDA (the maximum value of the artificial viscosity stability function), JLAM (the zone number of the largest value of LAMBDA), OMEGA (the normalized Courant stability conditions), JOMEGA (the zone number of the largest OMEGA value), GAMMA (the radiation diffusion stability control maximum value - not used in this pure hydrodynamics problem),

JGAM (the zone number of the most critical value of the radiation stability condition), JO (the next zone at which combining will take place), JSTAR (the largest zone through which radiation diffusion will be calculated, i.e., the outer boundary of the radiation diffusion - zero in this problem, since there is no radiation), JHAT (the last zone for which hydrodynamics will be calculated, i.e., the outer boundary), and IC (an iteration counter used in the implicit radiation routine - zero i.. this problem).

Outputs are listed for the first three cycles as an aid in code checking and to demonstrate the cycle-by-cycle progress of the finite difference method. Note that after the first cycle the kilobar boundary pressure (listed at j=0) causes some movement in the first (j=1) zone. This shows up as a non-zero velocity at the j=0 boundary and as an increase in density in the first zone. Corresponding increases in temperature, internal energy and pressure in that zone are also indicated, and because it is a compression, some artificial viscosity shows up.

On the second and third cycles, further growth of the movement is evident as the density continues to increase in the first zone and some compression reaches into the second zone. The very small and negative velocities that appear on the second and third cycles are a consequence of (and a measure of) the truncation error. Rounding the last figure of the pressures in adjacent zones slightly differently causes velocities of this small magnitude.

Note that the stability conditions have allowed the time increment to increase by 9/8ths on the second cycle, but have reduced Δt by 8/9ths <u>six</u> times to a value of $.98654\times10^{-4}$ on the third cycle to conform to the stability restriction from the growing artificial viscosity - indicating a growing shock in the first zone. The value of LAMBDA is near unity, while that of OMEGA is still quite small, indicating that the dominant stability is the viscosity or shock criterion (LAMBDA) rather than the Courant or sound speed condition (OMEGA).

By cycle 10, conditions in the first zone are well on their way toward representing a shock corresponding to the sudden onset of pressure we have exerted on the boundary. Between cycle 3 and 10 JHAT

has increased from 4 to 6 as more zones are set in motion. The density in the first zone is now nearly twice its original value.

By cycle 50, the shock is formed and is moving away from the boundary. Pressures, densities, temperatures, internal energies and velocities are all settling down to nearly constant values behind the front. At succeeding times (e.g., cycles 90, 130, 170, 210, and 250) all these quantities are within a percent or two of a constant value except for density, temperature, and internal energy in the first zone. The first zone or two are in this example somewhat anomalous, since they experienced a sudden onset of pressure - not a shock. The "definition" of a shock in such numerical schemes using artificiallv smeared fronts is one in which several zones of spread are necessary for normal propagation. When a boundary or initial condition prescribes a more rapid change or steeper gradients than are normally propagatable, the excessive heating of multiple or superimposed shocks is a natural consequence. Once a proper shock is developed, the appropriate Hugoniot values are generated.

The slight oscillations behind the shock cause small compressions and small artificial viscosity values. A linear viscosity term might be used to further damp such oscillations if desired. The last cycle run, cycle 614, has pressures as shown in Fig. 3 in comparison with the analytical exact solution (presuming a shock to have existed from the outset). The slight lag in the peak or shock front for the calculated pressure profile might have been eliminated by a set of initial conditions which more nearly represent the traveling shock including initial particle velocities as well as pressures in the first few zones and at the boundary itself.

The special display of cycles 263 and 264 allow a comparison of data just before and just after combining zones 5 and 6 into a single zone at 5. Note that on cycle 264 the mass at $j=5\frac{1}{2}$ (listed on line $j=6$) is the sum of the masses at lines 6 and 7 of cycle 263. The velocities, densities, energies, etc., are recomputed so as to conserve momentum and both kinetic and internal energy between the two zones and the new single zone. Mass conservation is automatic in the simple addition of masses. After combining, all the outer zones are shuffled

down to a zone number one less, and a new mass zone is added at the largest (right-most) zone boundary.

This simple test case problem takes about one minute for execution on the RAND machine combination 7040/7044 IBM.

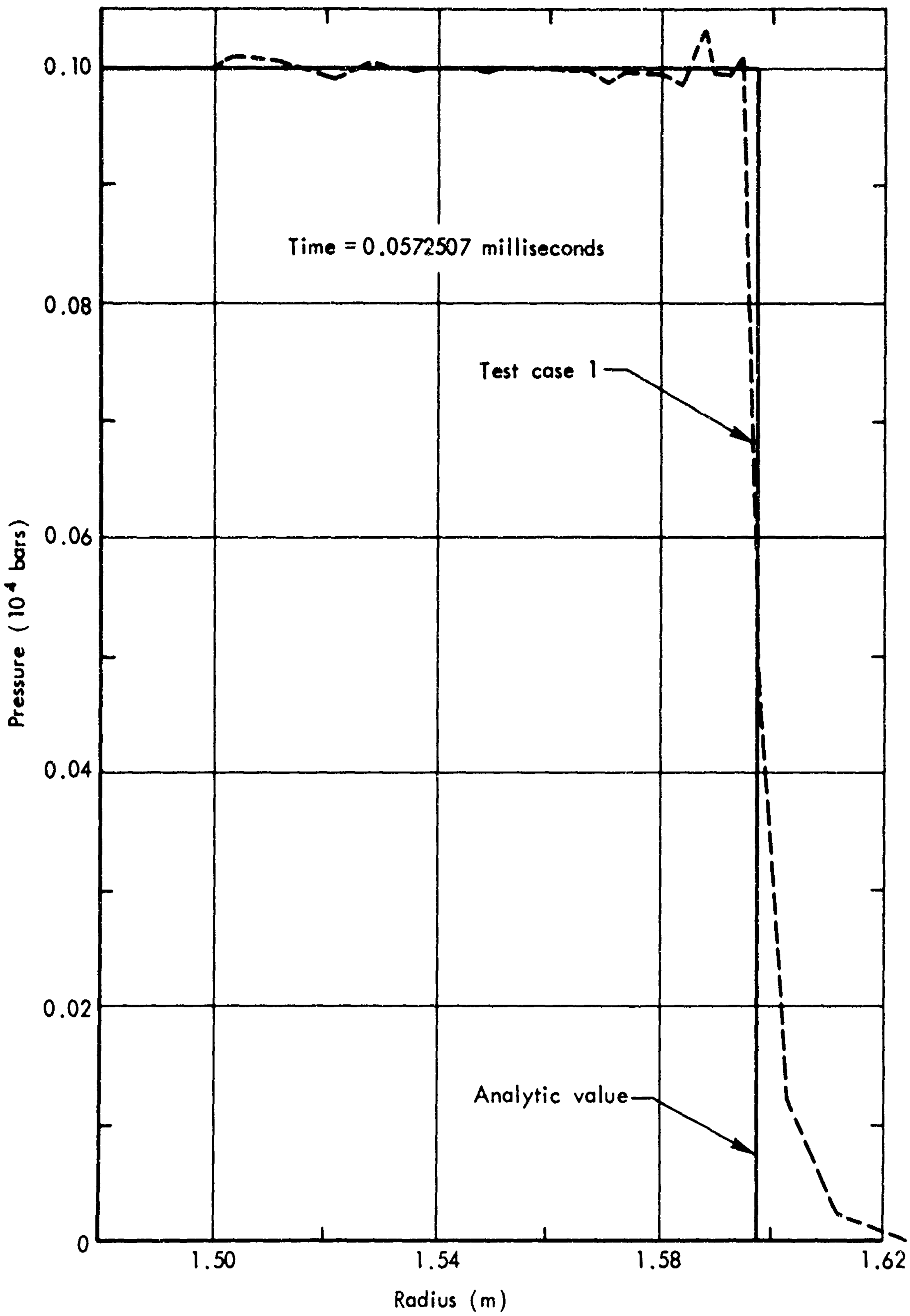


Fig. 3—Calculated pressure profile compared with exact value

HAROLD TEST 1.

IDEAL GAS

EQUATIONS OF STATE FOR THE GENERATOR.

```
      FUNCTION FP1001(E,V)
      FP1001= .4*E/V
      RETURN
      END

      FUNCTION FE1001(E,V)
      FE1001= .139*E
      RETURN
      END
```

EQUATION OF STATE FOR THE EXECUTOR.

```
      SUBROUTINE PET(MAT,T,V,P,E,J,C)
     P = .4*E/V
     RETURN
     END
```

DENSITY BOUNDARY CONDITION

```
      SUBROUTINE RBOUND (TDUM,RHO)
     *COMMON /IKA2/
      COMMON /VLC/ VL(1)
      RHO=1./VL(JMAX)
      RETURN
      END
```

*See page 255 for /IKA2/ definition.

```
HISTORYS.
EVERY   0.2500000E-01 MSECS. UNTIL   0.1000000E 01 MSECS.
EVERY   0.             MSECS. UNTIL   0.             MSECS.
EVERY   0.             MSECS. UNTIL   0.             MSECS.
EVERY   0.             MSECS. UNTIL   0.             MSECS.
EVERY   0.             MSECS. UNTIL   0.             MSECS.
EVERY   0.             MSECS. UNTIL   0.             MSECS.

PRINT OUTS.
EVERY     1 CYCLES UNTIL CYCLE     3
EVERY     7 CYCLES UNTIL CYCLE    10
EVERY    40 CYCLES UNTIL CYCLE   250
EVERY    13 CYCLES UNTIL CYCLE   263
EVERY     1 CYCLES UNTIL CYCLE   264
EVERY    50 CYCLES UNTIL CYCLE   614

ENERGY CHECKS.
EVERY  1000 CYCLES UNTIL CYCLE 10000
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0

PMIN BNDRY COND. P=
  0.1000000E 00 UNTIL   0.1000000E 12 MSECS.

RMIN=   0.1000000E 01

PLANE GEOMETRY.

REGION      1. MATERIAL  1001.
C1=  0.6000E 01. C2=  0.          . C3=  0.1600E 01. C4=  0.1600E 02. C5=  0.          . E0=  0.
```

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	EL
1	0.1010E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
2	0.1020E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
3	0.1030E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
4	0.1040E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
5	0.1050E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
6	0.1060E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
7	0.1070E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
8	0.1080E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
9	0.1090E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
10	0.1100E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
11	0.1110E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
12	0.1120E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.

J	R	U	TEM	VL	PP	EG	KP	KM	DMASS	FL
13	0.1130E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
14	0.1140E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
15	0.1150E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
16	0.1160E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
17	0.1170E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
18	0.1180E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
19	0.1190E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
20	0.1200E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
21	0.1210E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
22	0.1220E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
23	0.1230E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
24	0.1240E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
25	0.1250E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
26	0.1260E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
27	0.1270E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
28	0.1280E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
29	0.1290E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.
30	0.1300E 01	0.	0.2930E-01	0.9091E 03	0.9275E-04	0.2108E 00	0.	0.	0.1100E-04	0.

DT= 0.1000000E-03. DTP= 0.2000000E-03.

MASS ADD INFO.
JO= 5. JOS= 0. JOM= 23. DR= -0.7692300E-02.

PERCENTS.
X1= 0. . X2= 0. . X3= 0. . X4= 0.4000E-05. X5= 0.1250E 00. X6= 0.1000E-03.

Z2= 0.1000000E-03. JHAT= 3. JL= 29. Z1= 0. . JSTAR= 0.

NF= 614

```
                TRAJ*      ITEST 1. HYDRO ONLY. IDEAL GAS

      C1           C2           C3           C4          C5
  0.1000E 01  0.            0.1600E 01  0.1600E 02  0.

   JG   JOS   JOM        DRC
    5    0    23 -0.7632E-02

     Z1          Z2          JL      JHAT    JSTAR
  0.          0.1000E-03     29        3       0

     X1          X2          X3          X4          X5          X6
  0.          0.          0.          0.4000E-05  0.1250E 00  0.1000E-03

J     RADIUS          VELOCITY        DENSITY        TEMP          INTENG        PRESSURE      ARTVIS         MASS
0    1.00000E 00      0.              0.             0.            0.            0.            0.             0.

MATERIAL    1001
1    1.01000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
2    1.02000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
3    1.03000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
4    1.04000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
5    1.05000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05

   N      TIME            DT            LAMBDA      JLAM     OMEGA      JOMEGA        GAMMA        JGAM   JQ   JSTAR   JHAT   IC
   1   0.200000E-03   0.200000E-03   0.6786E 00      1    0.2034E-03     1     0.                 0     5     0      3     0

J     RADIUS          VELOCITY        DENSITY        TEMP          INTENG        PRESSURE      ARTVIS         MASS
0    1.00036E 00      1.816E 00       0.             0.            0.            1.000E-01     0.             0.

MATERIAL    1001
1    1.01000E 00      0.              1.141E-03      8.103E-02     5.830E-01     2.662E-04     1.109E-02      1.100E-05
2    1.02000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
3    1.03000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
4    1.04000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
5    1.05000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05

   N      TIME            DT            LAMBDA      JLAM     OMEGA      JOMEGA        GAMMA        JGAM   JQ   JSTAR   JHAT   IC
   2   0.425000E-03   0.225000E-03   0.9322E 00      1    0.8871E-03     1     0.                 0     5     0      3     0

J     RADIUS          VELOCITY        DENSITY        TEMP          INTENG        PRESSURE      ARTVIS         MASS
0    1.00154E 00      5.241E 00       0.             0.            0.            1.000E-01     0.             0.

MATERIAL    1001
1    1.01005E 00      2.176E-01       1.293E-03      1.432E 00     1.030E 01     5.330E-03     9.181E-02      1.100E-05
2    1.02000E 00     -1.757E-11       1.105E-03      2.945E-02     2.119E-01     9.370E-05     1.567E-04      1.100E-05
3    1.03000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
4    1.04000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05
5    1.05000E 00      0.              1.100E-03      2.930E-02     2.108E-01     9.275E-05     0.             1.100E-05

   N      TIME            DT            LAMBDA      JLAM     OMEGA      JOMEGA        GAMMA        JGAM   JQ   JSTAR   JHAT   IC
   3   0.523554E-03   0.985540E-04   0.8030E 00      1    0.1460E-02     1     0.                 0     5     0      4     0
```

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.00207E 00	5.325E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.01021E 00	1.643E 00	1.351E-03	1.707E 00	1.228E 01	6.634E-03	5.376E-02	1.100E-05
2	1.02000E 00	2.319E-03	1.124E-03	4.812E-02	3.462E-01	1.556E-04	9.000E-03	1.100E-05
3	1.03000E 00	-2.863E-09	1.100E-03	2.930E-02	2.108E-01	9.275E-05	1.928E-08	1.100E-05
4	1.04000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
5	1.05000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
6	1.06000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
4	0.634540E-03	0.110986E-03	0.9102E 00	1	0.2015E-02	1	0.	0	5	0	4	0
5	0.745526E-03	0.110986E-03	0.9486E 00	1	0.2706E-02	1	0.	0	5	0	5	0
6	0.856611E-03	0.110986E-03	0.9800E 00	1	0.3555E-02	1	0.	0	5	0	5	0
7	0.967597E-03	0.110986E-03	0.8980E 00	1	0.3628E-02	1	0.	0	5	0	5	0
8	0.106625E-02	0.986540E-04	0.9161E 00	1	0.4501E-02	1	0.	0	5	0	5	0
9	0.116491E-02	0.986540E-04	0.9337E 00	1	0.5533E-02	1	0.	0	5	0	5	0
10	0.126356E-02	0.986540E-04	0.9462E 00	1	0.6741E-02	1	0.	0	5	0	6	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.00747E 00	8.275E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.01291E 00	5.014E 00	2.022E-03	4.451E 00	3.202E 01	2.590E-02	6.266E-02	1.100E-05
2	1.02059E 00	1.760E 00	1.432E-03	9.743E-01	7.010E 00	4.014E-03	4.453E-02	1.100E-05
3	1.03002E 00	1.169E-01	1.166E-03	6.732E-02	4.843E-01	2.259E-04	9.368E-03	1.100E-05
4	1.04000E 00	1.330E-04	1.102E-03	2.933E-02	2.110E-01	9.305E-05	4.506E-05	1.100E-05
5	1.05000E 00	4.431E-09	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
6	1.06000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
7	1.07000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
8	1.08000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
11	0.136221E-02	0.986540E-04	0.9555E 00	1	0.8150E-02	1	0.	0	5	0	6	0
12	0.146087E-02	0.986540E-04	0.9612E 00	1	0.9784E-02	1	0.	0	5	0	6	0
13	0.155952E-02	0.986540E-04	0.9632E 00	1	0.1167E-01	1	0.	0	5	0	6	0
14	0.165818E-02	0.986540E-04	0.9609E 00	1	0.1383E-01	1	0.	0	5	0	6	0
15	0.175683E-02	0.986540E-04	0.9535E 00	1	0.1629E-01	1	0.	0	5	0	6	0
16	0.185548E-02	0.986540E-04	0.9400E 00	1	0.1907E-01	1	0.	0	5	0	6	0
17	0.195414E-02	0.986540E-04	0.9194E 00	1	0.2216E-01	1	0.	0	5	0	6	0
18	0.205279E-02	0.986540E-04	0.9046E 00	2	0.2557E-01	1	0.	0	5	0	7	0
19	0.215145E-02	0.986540E-04	0.9288E 00	2	0.2925E-01	1	0.	0	5	0	7	0
20	0.225010E-02	0.986540E-04	0.9510E 00	2	0.3316E-01	1	0.	0	5	0	7	0
21	0.234875E-02	0.986540E-04	0.9711E 00	2	0.3722E-01	1	0.	0	5	0	7	0
22	0.244741E-02	0.986540E-04	0.9884E 00	2	0.4132E-01	1	0.	0	5	0	7	0
23	0.254606E-02	0.986540E-04	0.8910E 00	2	0.3581E-01	1	0.	0	5	0	7	0
24	0.263375E-02	0.876925E-04	0.8962E 00	2	0.3846E-01	1	0.	0	5	0	7	0
25	0.272145E-02	0.876925E-04	0.9009E 00	2	0.4089E-01	1	0.	0	5	0	7	0
26	0.280914E-02	0.876925E-04	0.9013E 00	2	0.4301E-01	1	0.	0	5	0	7	0
27	0.289683E-02	0.876925E-04	0.8964E 00	2	0.4474E-01	1	0.	0	5	0	8	0
28	0.298452E-02	0.876925E-04	0.9962E 00	2	0.5825E-01	1	0.	0	5	0	8	0
29	0.308318E-02	0.986540E-04	0.9777E 00	2	0.5940E-01	1	0.	0	5	0	8	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JC	JSTAR	JHAT	IC
30	0.318133E-02	0.986540E-04	0.9720E 00	3	0.5981E-01	1	0.	0	5	0	8	0
31	0.328043E-02	0.986540E-04	0.9994E 00	3	0.5958E-01	1	0.	0	5	0	8	0
32	0.337914E-02	0.986540E-04	0.9106E 00	3	0.4649E-01	1	0.	0	5	0	8	0
33	0.346583E-02	0.876924E-04	0.9250E 00	3	0.4576E-01	1	0.	0	5	0	8	0
34	0.355452E-02	0.876924E-04	0.9381E 00	3	0.4572E-01	2	0.	0	5	0	8	0
35	0.364222E-02	0.876924E-04	0.9469E 00	3	0.4944E-01	2	0.	0	5	0	8	0
36	0.372991E-02	0.876924E-04	0.9503E 00	3	0.5273E-01	2	0.	0	5	0	9	0
37	0.381760E-02	0.876924E-04	0.9474E 00	3	0.5546E-01	2	0.	0	5	0	9	0
38	0.390529E-02	0.876924E-04	0.9371E 00	3	0.5750E-01	2	0.	0	5	0	9	0
39	0.399299E-02	0.876924E-04	0.9185E 00	3	0.5881E-01	2	0.	0	5	0	9	0
40	0.408068E-02	0.876924E-04	0.8910E 00	3	0.5941E-01	2	0.	0	5	0	9	0
41	0.416837E-02	0.876924E-04	0.8919E 00	4	0.5939E-01	2	0.	0	5	0	9	0
42	0.425606E-02	0.876924E-04	0.9145E 00	4	0.5891E-01	2	0.	0	5	0	9	0
43	0.434375E-02	0.876924E-04	0.9345E 00	4	0.5816E-01	2	0.	0	5	0	9	0
44	0.443145E-02	0.876924E-04	0.9514E 00	4	0.5733E-01	2	0.	0	5	0	9	0
45	0.451914E-02	0.876924E-04	0.9639E 00	4	0.5458E-01	2	0.	0	5	0	9	0
46	0.460683E-02	0.876924E-04	0.9715E 00	4	0.5774E-01	3	0.	0	5	0	9	0
47	0.469453E-02	0.876924E-04	0.9730E 00	4	0.6115E-01	3	0.	0	5	0	10	0
48	0.478222E-02	0.876924E-04	0.9678E 00	4	0.6378E-01	3	0.	0	5	0	10	0
49	0.486991E-02	0.876924E-04	0.9544E 00	4	0.6556E-01	3	0.	0	5	0	10	0
50	0.495760E-02	0.876924E-04	0.9319E 00	4	0.6651E-01	3	0.	0	5	0	10	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.04105E 00	8.746E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.04354E 00	8.960E 00	4.416E-03	7.926E 00	5.702E 01	1.007E-01	0.	1.100E-05
2	1.04553E 00	8.959E 00	5.509E-03	6.395E 00	4.601E 01	1.014E-01	1.680E-04	1.100E-05
3	1.04729E 00	8.739E 00	6.248E-03	5.822E 00	4.188E 01	1.047E-01	2.690E-04	1.100E-05
4	1.04968E 00	7.157E 00	4.618E-03	4.721E 00	3.396E 01	6.274E-02	3.370E-02	1.100E-05
5	1.05402E 00	4.505E 00	2.532E-03	2.572E 00	1.850E 01	1.874E-02	5.201E-02	1.100E-05
6	1.06036E 00	1.815E 00	1.585E-03	7.567E-01	5.444E 00	3.451E-03	3.383E-02	1.100E-05
7	1.07006E 00	2.205E-01	1.209E-03	8.087E-02	5.818E-01	2.813E-04	9.149E-03	1.100E-05
8	1.08000E 00	1.341E-03	1.107E-03	2.944E-02	2.118E-01	9.377E-05	1.594E-04	1.100E-05
9	1.09000E 00	2.397E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	4.670E-09	1.100E-05
10	1.10000E 00	-3.772E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	9.576E-11	1.100E-05
11	1.11000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
12	1.12000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
51	0.504530E-02	0.876924E-04	0.8991E 00	4	0.6671E-01	3	0.	0	5	0	10	0
52	0.513299E-02	0.876924E-04	0.9069E 00	5	0.6632E-01	3	0.	0	5	0	10	0
53	0.522068E-02	0.876924E-04	0.9294E 00	5	0.6555E-01	3	0.	0	5	0	10	0
54	0.530837E-02	0.876924E-04	0.9489E 00	5	0.6461E-01	3	0.	0	5	0	10	0
55	0.539606E-02	0.876924E-04	0.9647E 00	5	0.6370E-01	3	0.	0	5	0	10	0
56	0.548376E-02	0.876924E-04	0.9759E 00	5	0.6295E-01	3	0.	0	5	0	10	0
57	0.557145E-02	0.876924E-04	0.9817E 00	5	0.6245E-01	3	0.	0	5	0	10	0
58	0.565914E-02	0.876924E-04	0.9808E 00	5	0.6553E-01	4	0.	0	5	0	11	0
59	0.574683E-02	0.876924E-04	0.9727E 00	5	0.6779E-01	4	0.	0	5	0	11	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
60	0.583453E-02	0.876924E-04	0.9559E 00	5	0.6910E-01	4	0.	0	5	0	11	0
61	0.592222E-02	0.876924E-04	0.9289E 00	5	0.6950E-01	4	0.	0	5	0	11	0
62	0.600991E-02	0.876924E-04	0.8915E 00	6	0.6913E-01	4	0.	[illegible]	5	0	11	0
63	0.609760E-02	0.876924E-04	0.9154E 00	6	0.6820E-01	4	0.		5	0	11	0
64	0.618530E-02	0.876924E-04	0.9366E 00	6	0.6694E-01	4	0.		5	0	11	0
65	0.627299E-02	0.876924E-04	0.9545E 00	6	0.6562E-01	4	0.		5	0	11	0
66	0.636068E-02	0.876924E-04	0.9679E 00	6	0.6444E-01	4	0.	0	5	0	11	0
67	0.644837E-02	0.876924E-04	0.9764E 00	6	0.6353E-01	4	0.	0	5	0	11	0
68	0.653607E-02	0.876924E-04	0.9788E 00	6	0.6388E-01	5	0.	0	5	0	11	0
69	0.662376E-02	0.876924E-04	0.9747E 00	6	0.6651E-01	5	0.	0	5	0	12	0
70	0.671145E-02	0.876924E-04	0.9625E 00	6	0.6815E-01	5	0.	0	5	0	12	0
71	0.679914E-02	0.876924E-04	0.9414E 00	6	0.6882E-01	5	0.	0	5	0	12	0
72	0.688684E-02	0.876924E-04	0.9098E 00	6	0.6865E-01	5	0.	0	5	0	12	0
73	0.697453E-02	0.876924E-04	0.8934E 00	7	0.6783E-01	5	0.	0	5	0	12	0
74	0.706222E-02	0.876924E-04	0.9155E 00	7	0.6665E-01	5	0.	0	5	0	12	0
75	0.714991E-02	0.876924E-04	0.9348E 00	7	0.6683E-01	4	0.	0	5	0	12	0
76	0.723761E-02	0.876924E-04	0.9505E 00	7	0.6713E-01	4	0.	0	5	0	12	0
77	0.732530E-02	0.876924E-04	0.9617E 00	7	0.6704E-01	4	0.	0	5	0	12	0
78	0.741299E-02	0.876924E-04	0.9680E 00	7	0.6657E-01	4	0.	0	5	0	12	0
79	0.750068E-02	0.876924E-04	0.9685E 00	7	0.6578E-01	4	0.	0	5	0	13	0
80	0.758837E-02	0.876924E-04	0.9626E 00	7	0.6585E-01	6	0.	0	5	0	13	0
81	0.767607E-02	0.876924E-04	0.9489E 00	7	0.6728E-01	6	0.	0	5	0	13	0
82	0.776376E-02	0.876924E-04	0.9263E 00	7	0.6790E-01	6	0.	0	5	0	13	0
83	0.785145E-02	0.876924E-04	0.8937E 00	7	0.6783E-01	6	0.	0	5	0	13	0
84	0.793914E-02	0.876924E-04	0.8921E 00	8	0.6727E-01	6	0.	0	5	0	13	0
85	0.802684E-02	0.876924E-04	0.9138E 00	8	0.6778E-01	5	0.	0	5	0	13	0
86	0.811453E-02	0.876924E-04	0.9328E 00	8	0.6797E-01	5	0.	0	5	0	13	0
87	0.820222E-02	0.876924E-04	0.9483E 00	8	0.6773E-01	5	0.	0	5	0	13	0
88	0.828991E-02	0.876924E-04	0.9596E 00	8	0.6708E-01	5	0.	0	5	0	13	0
89	0.837761E-02	0.876924E-04	0.9661E 00	8	0.6614E-01	5	0.	0	5	0	13	0
90	0.846530E-02	0.876924E-04	0.9668E 00	8	0.6562E-01	4	0.	0	5	0	14	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.07176E 00	8.816E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.07425E 00	8.534E 00	4.414E-03	7.924E 00	5.700E 01	1.007E-01	4.372E-04	1.100E-05
2	1.07627E 00	8.795E 00	5.443E-03	6.363E 00	4.578E 01	9.966E-02	0.	1.100E-05
3	1.07811E 00	8.744E 00	6.102E-03	5.728E 00	4.121E 01	9.894E-02	4.831E-05	1.100E-05
4	1.07983E 00	8.648E 00	6.365E-03	5.535E 00	3.982E 01	1.014E-01	1.756E-04	1.100E-05
5	1.08155E 00	8.780E 00	6.393E-03	5.441E 00	3.915E 01	1.001E-01	0.	1.100E-05
6	1.08328E 00	8.776E 00	6.364E-03	5.400E 00	3.885E 01	9.890E-02	2.668E-07	1.100E-05
7	1.08501E 00	8.352E 00	6.367E-03	5.376E 00	3.868E 01	9.851E-02	3.394E-03	1.100E-05
8	1.08781E 00	6.423E 00	3.929E-03	4.081E 00	2.936E 01	4.614E-02	4.258E-02	1.100E-05
9	1.09288E 00	3.665E 00	2.171E-03	1.930E 00	1.389E 01	1.206E-02	4.839E-02	1.100E-05
10	1.10053E 00	1.185E 00	1.437E-03	4.459E-01	3.208E 00	1.845E-03	2.615E-02	1.100E-05
11	1.11002E 00	7.692E-02	1.159E-03	4.302E-02	3.095E-01	1.435E-04	4.251E-03	1.100E-05
12	1.12000E 00	1.199E-04	1.102E-03	2.932E-02	2.110E-01	9.300E-05	1.950E-05	1.100E-05
13	1.13000E 00	-7.769E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	9.469E-11	1.100E-05
14	1.14000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
15	1.15000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
16	1.16000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA		GAMMA	JGAM	JO	JSTAR	JHAT	IC
91	0.855299E-02	0.876924E-04	0.9610E 00	8	0.6613E-01	7	0.		0	5	0	14	0
92	0.864368E-02	0.876924E-04	0.9472E 00	8	0.6761E-01	7	0.		0	5	0	14	0
93	0.872337E-02	0.876924E-04	0.9242E 00	8	0.6825E-01	7	0.		0	5	0	14	0
94	0.881907E-02	0.876924E-04	0.8910E 00	8	0.6818E-01	7	0.		0	5	0	14	0
95	0.890376E-02	0.876924E-04	0.8953E 00	9	0.6756E-01	7	0.		0	5	0	14	0
96	0.899145E-02	0.876924E-04	0.9171E 00	9	0.6688E-01	6	0.		0	5	0	14	0
97	0.907914E-02	0.876924E-04	0.9359E 00	9	0.6703E-01	6	0.		0	5	0	14	0
98	0.916684E-02	0.876924E-04	0.9510E 00	9	0.6695E-01	6	0.		0	5	0	14	0
99	0.925453E-02	0.876924E-04	0.9619E 00	9	0.6665E-01	6	0.		0	5	0	14	0
100	0.934222E-02	0.876924E-04	0.9673E 00	9	0.6698E-01	5	0.		0	5	0	14	0
101	0.942991E-02	0.876924E-04	0.9668E 00	9	0.6743E-01	5	0.		0	5	0	15	0
102	0.951761E-02	0.876924E-04	0.9593E 00	9	0.6750E-01	5	0.		0	5	0	15	0
103	0.960530E-02	0.876924E-04	0.9438E 00	9	0.6758E-01	8	0.		0	5	0	15	0
104	0.969299E-02	0.876924E-04	0.9188E 00	9	0.6799E-01	8	0.		0	5	0	15	0
105	0.978068E-02	0.876924E-04	0.9939E 00	9	0.8572E-01	8	0.		0	5	0	15	0
106	0.987934E-02	0.986539E-04	0.9022E 00	10	0.6699E-01	7	0.		0	5	0	15	0
107	0.996703E-02	0.876924E-04	0.9213E 00	10	0.6769E-01	7	0.		0	5	0	15	0
108	0.100547E-01	0.876924E-04	0.9383E 00	10	0.6807E-01	7	0.		0	5	0	15	0
109	0.101424E-01	0.876924E-04	0.9522E 00	10	0.6808E-01	7	0.		0	5	0	15	0
110	0.102301E-01	0.876924E-04	0.9615E 00	10	0.6769E-01	7	0.		0	5	0	15	0
111	0.103173E-01	0.876924E-04	0.9658E 00	10	0.6699E-01	7	0.		0	5	0	15	0
112	0.104055E-01	0.876924E-04	0.9637E 00	10	0.6679E-01	6	0.		0	5	0	16	0
113	0.104932E-01	0.876924E-04	0.9547E 00	10	0.6692E-01	6	0.		0	5	0	16	0
114	0.105809E-01	0.876924E-04	0.9376E 00	10	0.6780E-01	9	0.		0	5	0	16	0
115	0.106686E-01	0.876924E-04	0.9111E 00	10	0.6821E-01	9	0.		0	5	0	16	0
116	0.107563E-01	0.876924E-04	0.9889E 00	11	0.8609E-01	9	0.		0	5	0	16	0
117	0.108549E-01	0.986539E-04	0.9069E 00	11	0.6786E-01	8	0.		0	5	0	16	0
118	0.109425E-01	0.876924E-04	0.9256E 00	11	0.6815E-01	8	0.		0	5	0	16	0
119	0.110303E-01	0.876924E-04	0.9424E 00	11	0.6809E-01	8	0.		0	5	0	16	0
120	0.111180E-01	0.876924E-04	0.9558E 00	11	0.6770E-01	8	0.		0	5	0	16	0
121	0.112057E-01	0.876924E-04	0.9646E 00	11	0.6704E-01	8	0.		0	5	0	16	0
122	0.112934E-01	0.876924E-04	0.9681E 00	11	0.6743E-01	7	0.		0	5	0	16	0
123	0.113811E-01	0.876924E-04	0.9651E 00	11	0.6798E-01	7	0.		0	5	0	17	0
124	0.114688E-01	0.876924E-04	0.9546E 00	11	0.6817E-01	7	0.		0	5	0	17	0
125	0.115565E-01	0.876924E-04	0.9355E 00	11	0.6847E-01	10	0.		0	5	0	17	0
126	0.116441E-01	0.876924E-04	0.9064E 00	11	0.6868E-01	10	0.		0	5	0	17	0
127	0.117318E-01	0.876924E-04	0.9968E 00	12	0.8640E-01	10	0.		0	5	0	17	0
128	0.118305E-01	0.985539E-04	0.9135E 00	12	0.6766E-01	9	0.		0	5	0	17	0
129	0.119182E-01	0.876924E-04	0.9315E 00	12	0.6805E-01	9	0.		0	5	0	17	0
130	0.120059E-01	0.876924E-04	0.9472E 00	12	0.6819E-01	9	0.		0	5	0	17	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.10261E 00	8.651E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1C01							
1	1.10515E 00	8.779E 00	4.339E-03	7.868E 00	5.661E 01	9.825E-02	0.	1.100E-05
2	1.10715E 00	8.656E 00	5.508E-03	6.393E 00	4.599E 01	1.013E-01	2.522E-04	1.100E-05
3	1.10896E 00	8.712E 00	6.060E-03	5.750E 00	4.137E 01	1.003E-01	0.	1.100E-05
4	1.11072E 00	8.769E 00	6.241E-03	5.491E 00	3.950E 01	9.862E-02	0.	1.100E-05
5	1.11243E 00	8.668E 00	6.434E-03	5.454E 00	3.924E 01	1.010E-01	1.981E-04	1.100E-05
6	1.11413E 00	8.691E 00	6.478E-03	5.438E 00	3.912E 01	1.014E-01	0.	1.100E-05
7	1.11585E 00	8.779E 00	6.376E-03	5.379E 00	3.870E 01	9.870E-02	0.	1.100E-05
8	1.11755E 00	8.682E 00	6.479E-03	5.386E 00	3.875E 01	1.004E-01	1.800E-04	1.100E-05
9	1.11923E 00	8.666E 00	6.575E-03	5.390E 00	3.878E 01	1.020E-01	5.247E-06	1.100E-05
10	1.12093E 00	8.782E 00	6.471E-03	5.334E 00	3.836E 01	9.934E-02	0.	1.100E-05
11	1.12280E 00	7.912E 00	5.887E-03	5.113E 00	3.678E 01	8.661E-02	1.309E-02	1.100E-05
12	1.12614E 00	5.054E 00	3.289E-03	3.447E 00	2.480E 01	3.262E-02	4.885E-02	1.100E-05
13	1.13195E 00	2.868E 00	1.892E-03	1.375E 00	9.889E 00	7.483E-03	4.317E-02	1.100E-05
14	1.14026E 00	6.819E-01	1.325E-03	2.370E-01	1.705E 00	9.039E-04	1.877E-02	1.100E-05
15	1.15000E 00	1.980E-02	1.128E-03	3.184E-02	2.290E-01	1.034E-04	1.480E-03	1.100E-05
16	1.16000E 00	5.927E-06	1.100E-03	2.930E-02	2.108E-01	9.280E-05	1.283E-06	1.100E-05
17	1.17000E 00	-7.070E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	9.469E-11	1.100E-05
18	1.18000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
19	1.19000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
131	0.120336E-01	0.876924E-04	0.9593E 00	12	0.6805E-01	9	0.	0	5	0	17	0
132	0.121813E-01	0.876924E-04	0.9665E 00	12	0.6766E-01	9	0.	0	5	0	17	0
133	0.122690E-01	0.876924E-04	0.9681E 00	12	0.6793E-01	8	0.	0	5	0	18	0
134	0.123566E-01	0.876924E-04	0.9627E 00	12	0.6800E-01	8	0.	0	5	0	18	0
135	0.124443E-01	0.876924E-04	0.9499E 00	12	0.6778E-01	8	0.	0	5	0	18	0
136	0.125320E-01	0.876924E-04	0.9282E 00	12	0.6845E-01	11	0.	0	5	0	18	0
137	0.126197E-01	0.876924E-04	0.8960E 00	12	0.6846E-01	11	0.	0	5	0	18	0
138	0.127074E-01	0.876924E-04	0.8911E 00	13	0.6795E-01	11	0.	0	5	0	18	0
139	0.127951E-01	0.876924E-04	0.9132E 00	13	0.6855E-01	10	0.	0	5	0	18	0
140	0.128828E-01	0.876924E-04	0.9325E 00	13	0.6892E-01	10	0.	0	5	0	18	0
141	0.129705E-01	0.876924E-04	0.9484E 00	13	0.6891E-01	10	0.	0	5	0	18	0
142	0.130582E-01	0.876924E-04	0.9599E 00	13	0.6851E-01	10	0.	0	5	0	18	0
143	0.131459E-01	0.876924E-04	0.9665E 00	13	0.6778E-01	10	0.	0	5	0	18	0
144	0.132336E-01	0.876923E-04	0.9677E 00	13	0.6766E-01	9	0.	0	5	0	19	0
145	0.133213E-01	0.876923E-04	0.9620E 00	13	0.6802E-01	9	0.	0	5	0	19	0
146	0.134090E-01	0.876923E-04	0.9486E 00	13	0.6812E-01	9	0.	0	5	0	19	0
147	0.134966E-01	0.876923E-04	0.9261E 00	13	0.6874E-01	12	0.	0	5	0	19	0
148	0.135843E-01	0.876923E-04	0.8934E 00	13	0.6874E-01	12	0.	0	5	0	19	0
149	0.136720E-01	0.876923E-04	0.8941E 00	14	0.6822E-01	12	0.	0	5	0	19	0
150	0.137597E-01	0.876923E-04	0.9160E 00	14	0.6837E-01	11	0.	0	5	0	19	0
151	0.138474E-01	0.876923E-04	0.9353E 00	14	0.6852E-01	11	0.	0	5	0	19	0
152	0.139351E-01	0.876923E-04	0.9507E 00	14	0.6837E-01	11	0.	0	5	0	19	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
153	0.140223E-01	0.876923E-04	0.9620E 00	14	0.6796E-01	11	0.	0	5	0	19	0
154	0.141103E-01	0.876923E-04	0.9681E 00	14	0.6811E-01	10	0.	0	5	0	19	0
155	0.141982E-01	0.876923E-04	0.9684E 00	14	0.6864E-01	10	0.	0	5	0	20	0
156	0.142859E-01	0.876923E-04	0.9617E 00	14	0.6880E-01	10	0.	0	5	0	20	0
157	0.143736E-01	0.876923E-04	0.9470E 00	14	0.6858E-01	10	0.	0	5	0	20	0
158	0.144613E-01	0.876923E-04	0.9231E 00	14	0.6870E-01	13	0.	0	5	0	20	0
159	0.145490E-01	0.876923E-04	0.9995E 00	14	0.8674E-01	13	0.	0	5	0	20	0
160	0.146475E-01	0.985539E-04	0.9015E 00	15	0.6788E-01	12	0.	0	5	0	20	0
161	0.147353E-01	0.876923E-04	0.9210E 00	15	0.6846E-01	12	0.	0	5	0	20	0
162	0.148230E-01	0.876923E-04	0.9385E 00	15	0.6876E-01	12	0.	0	5	0	20	0
163	0.149107E-01	0.876923E-04	0.9529E 00	15	0.6872E-01	12	0.	0	5	0	20	0
164	0.149984E-01	0.876923E-04	0.9628E 00	15	0.6834E-01	12	0.	0	5	0	20	0
165	0.150861E-01	0.876923E-04	0.9672E 00	15	0.6778E-01	11	0.	0	5	0	20	0
166	0.151738E-01	0.876923E-04	0.9659E 00	15	0.6806E-01	11	0.	0	5	0	21	0
167	0.152615E-01	0.876923E-04	0.9573E 00	15	0.6810E-01	11	0.	0	5	0	21	0
168	0.153491E-01	0.876923E-04	0.9407E 00	15	0.6816E-01	14	0.	0	5	0	21	0
169	0.154368E-01	0.876923E-04	0.9144E 00	15	0.6856E-01	14	0.	0	5	0	21	0
170	0.155245E-01	0.876923E-04	0.9978E 00	16	0.8647E-01	14	0.	0	5	0	21	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.13327E 00	8.729E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.13575E 00	8.658E 00	4.448E-03	7.946E 00	5.716E 01	1.017E-01	6.724E-05	1.100E-05
2	1.13779E 00	8.738E 00	5.392E-03	6.337E 00	4.559E 01	9.833E-02	0.	1.100E-05
3	1.13963E 00	8.692E 00	6.051E-03	5.747E 00	4.134E 01	1.001E-01	3.789E-05	1.100E-05
4	1.14133E 00	8.665E 00	6.378E-03	5.538E 00	3.985E 01	1.017E-01	1.396E-05	1.100E-05
5	1.14307E 00	8.738E 00	6.334E-03	5.420E 00	3.899E 01	9.878E-02	0.	1.100E-05
6	1.14473E 00	8.705E 00	6.391E-03	5.409E 00	3.891E 01	9.948E-02	2.018E-05	1.100E-05
7	1.14647E 00	8.656E 00	6.525E-03	5.428E 00	3.905E 01	1.019E-01	4.715E-05	1.100E-05
8	1.14818E 00	8.736E 00	6.443E-03	5.374E 00	3.866E 01	9.963E-02	0.	1.100E-05
9	1.14989E 00	8.724E 00	6.424E-03	5.339E 00	3.841E 01	9.871E-02	2.423E-06	1.100E-05
10	1.15156E 00	8.652E 00	6.586E-03	5.371E 00	3.864E 01	1.018E-01	1.043E-04	1.100E-05
11	1.15324E 00	8.719E 00	6.540E-03	5.346E 00	3.846E 01	1.006E-01	0.	1.100E-05
12	1.15495E 00	8.755E 00	6.435E-03	5.307E 00	3.818E 01	9.827E-02	0.	1.100E-05
13	1.15663E 00	8.653E 00	6.567E-03	5.349E 00	3.848E 01	1.011E-01	2.043E-04	1.100E-05
14	1.15830E 00	8.680E 00	5.600E-03	5.360E 00	3.856E 01	1.018E-01	0.	1.100E-05
15	1.16048E 00	7.315E 00	5.040E-03	4.726E 00	3.400E 01	6.854E-02	2.741E-02	1.100E-05
16	1.16453E 00	4.777E 00	2.712E-03	2.756E 00	1.983E 01	2.151E-02	5.101E-02	1.100E-05
17	1.17118E 00	2.065E 00	1.655E-03	8.865E-01	6.378E 00	4.222E-03	3.588E-02	1.100E-05
18	1.18009E 00	3.085E-01	1.234E-03	1.068E-01	7.684E-01	3.793E-04	1.132E-02	1.100E-05
19	1.19000E 00	2.985E-03	1.110E-03	2.959E-02	2.129E-01	9.456E-05	3.106E-04	1.100E-05
20	1.20000E 00	1.054E-07	1.100E-03	2.930E-02	2.108E-01	9.275E-05	2.753E-08	1.100E-05
21	1.21000E 00	-5.029E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	9.576E-11	1.100E-05
22	1.22000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
23	1.23000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
171	0.156232E-01	0.986539E-04	0.9060E 00	16	0.6851E-01	10	0.	0	5	0	21	0
172	0.157109E-01	0.876923E-04	0.9248E 00	16	0.6866E-01	13	0.	0	5	0	21	0
173	0.157986E-01	0.876923E-04	0.9417E 00	16	0.6869E-01	13	0.	0	5	0	21	0
174	0.158863E-01	0.876923E-04	0.9552E 00	16	0.6837E-01	13	0.	0	5	0	21	0
175	0.159739E-01	0.876923E-04	0.9641E 00	16	0.6774E-01	13	0.	0	5	0	21	0
176	0.160616E-01	0.876923E-04	0.9676E 00	16	0.6797E-01	12	0.	0	5	0	21	0
177	0.161493E-01	0.876923E-04	0.9649E 00	16	0.6847E-01	12	0.	0	5	0	22	0
178	0.162370E-01	0.876923E-04	0.9548E 00	16	0.6864E-01	12	0.	0	5	0	22	0
179	0.163247E-01	0.876923E-04	0.9361E 00	16	0.6847E-01	12	0.	0	5	0	22	0
180	0.164124E-01	0.876923E-04	0.9076E 00	16	0.6865E-01	15	0.	0	5	0	22	0
181	0.165001E-01	0.876923E-04	0.9943E 00	17	0.8639E-01	15	0.	0	5	0	22	0
182	0.165988E-01	0.986539E-04	0.9114E 00	17	0.6794E-01	14	0.	0	5	0	22	0
183	0.166864E-01	0.876923E-04	0.9294E 00	17	0.6829E-01	14	0.	0	5	0	22	0
184	0.167741E-01	0.876923E-04	0.9454E 00	17	0.6837E-01	14	0.	0	5	0	22	0
185	0.168618E-01	0.876923E-04	0.9577E 00	17	0.6815E-01	14	0.	0	5	0	22	0
186	0.169495E-01	0.876923E-04	0.9654E 00	17	0.6817E-01	10	0.	0	5	0	22	0
187	0.170372E-01	0.876923E-04	0.9673E 00	17	0.6832E-01	13	0.	0	5	0	23	0
188	0.171249E-01	0.876923E-04	0.9625E 00	17	0.6849E-01	13	0.	0	5	0	23	0
189	0.172126E-01	0.876923E-04	0.9503E 00	17	0.6833E-01	13	0.	0	5	0	23	0
190	0.173003E-01	0.876923E-04	0.9292E 00	17	0.6834E-01	16	0.	0	5	0	23	0
191	0.173880E-01	0.876923E-04	0.8979E 00	17	0.6839E-01	16	0.	0	5	0	23	0
192	0.174757E-01	0.876923E-04	0.9999E 00	18	0.8624E-01	12	0.	0	5	0	23	0
193	0.175743E-01	0.986538E-04	0.9156E 00	18	0.6849E-01	12	0.	0	5	0	23	0
194	0.176620E-01	0.876923E-04	0.9328E 00	18	0.6872E-01	15	0.	0	5	0	23	0
195	0.177497E-01	0.876923E-04	0.9478E 00	18	0.6870E-01	15	0.	0	5	0	23	0
196	0.178374E-01	0.876923E-04	0.9592E 00	18	0.6832E-01	15	0.	0	5	0	23	0
197	0.179251E-01	0.876923E-04	0.9655E 00	18	0.6767E-01	11	0.	0	5	0	23	0
198	0.180128E-01	0.876923E-04	0.9661E 00	18	0.6789E-01	14	0.	0	5	0	24	0
199	0.181005E-01	0.876923E-04	0.9601E 00	18	0.6817E-01	14	0.	0	5	0	24	0
200	0.181882E-01	0.876923E-04	0.9463E 00	18	0.6817E-01	14	0.	0	5	0	24	0
201	0.182759E-01	0.876923E-04	0.9231E 00	18	0.6849E-01	17	0.	0	5	0	24	0
202	0.183636E-01	0.876923E-04	0.8899E 00	18	0.6846E-01	17	0.	0	5	0	24	0
203	0.184513E-01	0.876923E-04	0.8940E 00	19	0.6817E-01	13	0.	0	5	0	24	0
204	0.185389E-01	0.876923E-04	0.9157E 00	19	0.6824E-01	16	0.	0	5	0	24	0
205	0.186266E-01	0.876923E-04	0.9345E 00	19	0.6842E-01	16	0.	0	5	0	24	0
206	0.187143E-01	0.876923E-04	0.9499E 00	19	0.6829E-01	16	0.	0	5	0	24	0
207	0.188020E-01	0.876923E-04	0.9609E 00	19	0.6786E-01	16	0.	0	5	0	24	0
208	0.188837E-01	0.876923E-04	0.9668E 00	19	0.6809E-01	12	0.	0	5	0	24	0
209	0.189774E-01	0.876923E-04	0.9668E 00	19	0.6844E-01	15	0.	0	5	0	25	0
210	0.190651E-01	0.876923E-04	0.9598E 00	19	0.6863E-01	15	0.	0	5	0	25	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.16403E 00	8.693E 00	0.	0.	0.	1.000E-01	0.	0.

MATERIAL 1001

1	1.16657E 00	8.705E 00	4.339E-03	7.866E 00	5.659E 01	9.822E-02	0.	1.100E-05
2	1.16856E 00	8.675E 00	5.521E-03	6.397E 00	4.602E 01	1.016E-01	1.531E-05	1.100E-05
3	1.17038E 00	8.714E 00	6.031E-03	5.739E 00	4.129E 01	9.959E-02	0.	1.100E-05
4	1.17215E 00	8.704E 00	6.238E-03	5.489E 00	3.949E 01	9.852E-02	1.634E-06	1.100E-05
5	1.17385E 00	8.669E 00	6.455E-03	5.460E 00	3.928E 01	1.014E-01	2.394E-05	1.100E-05

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
6	1.17556E 00	8.711E 00	6.430E-03	5.422E 00	3.901E 01	1.003E-01	0.	1.100E-05
7	1.17729E 00	8.716E 00	6.356E-03	5.371E 00	3.864E 01	9.823E-02	0.	1.100E-05
8	1.17898E 00	8.665E 00	6.505E-03	5.394E 00	3.880E 01	1.010E-01	5.098E-05	1.100E-05
9	1.18067E 00	8.698E 00	6.533E-03	5.375E 00	3.867E 01	1.011E-01	0.	1.100E-05
10	1.18238E 00	8.733E 00	[illegible].420E-03	5.316E 00	3.824E 01	9.821E-02	0.	1.100E-05
11	1.18407E 00	8.666E 00	6.520E-03	5.339E 00	3.841E 01	1.002E-01	8.841E-05	1.100E-05
12	1.18574E 00	8.681E 00	6.593E-03	5.357E 00	3.854E 01	1.016E-01	0.	1.100E-05
13	1.18744E 00	8.745E 00	6.457E-03	5.312E 00	3.822E 01	9.871E-02	0.	1.100E-05
14	1.18914E 00	8.682E 00	6.483E-03	5.321E 00	3.828E 01	9.926E-02	7.758E-05	1.100E-05
15	1.19080E 00	8.659E 00	6.614E-03	5.362E 00	3.858E 01	1.021E-01	9.976E-06	1.100E-05
16	1.19249E 00	8.749E 00	6.496E-03	5.323E 00	3.830E 01	9.952E-02	0.	1.100E-05
17	1.19420E 00	8.707E 00	6.456E-03	5.307E 00	3.818E 01	9.860E-02	3.436E-05	1.100E-05
18	1.19588E 00	8.433E 00	6.536E-03	5.332E 00	3.836E 01	1.003E-01	1.465E-03	1.100E-05
19	1.19849E 00	6.650E 00	4.220E-03	4.230E 00	3.043E 01	5.137E-02	3.908E-02	1.100E-05
20	1.20327E 00	3.941E 00	2.298E-03	2.122E 00	1.527E 01	1.404E-02	4.935E-02	1.100E-05
21	1.21067E 00	1.393E 00	1.488E-03	5.391E-01	3.879E 00	2.308E-03	2.855E-02	1.100E-05
22	1.22003E 00	1.160E-01	1.175E-03	5.213E-02	3.750E-01	1.763E-04	5.715E-03	1.100E-05
23	1.23000E 00	3.097E-04	1.103E-03	2.934E-02	2.111E-01	9.316E-05	4.430E-05	1.100E-05
24	1.24000E 00	-7.676E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	3.809E-10	1.100E-05
25	1.25000E 00	-1.257E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
26	1.26000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
27	1.27000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
211	0.191528E-01	0.876923E-04	0.9449E 00	19	0.6846E-01	15	0.	0	5	0	25	0
212	0.192405E-01	0.876923E-04	0.9208E 00	19	0.6852E-01	18	0.	0	5	0	25	0
213	0.193282E-01	0.876923E-04	0.9965E 00	19	0.8651E-01	18	0.	0	5	0	25	0
214	0.194268E-01	0.986538E-04	0.9011E 00	20	0.6788E-01	14	0.	0	5	0	25	0
215	0.195145E-01	0.876923E-04	0.9207E 00	20	0.6830E-01	17	0.	0	5	0	25	0
216	0.196022E-01	0.876923E-04	0.9379E 00	20	0.6855E-01	17	0.	0	5	0	25	0
217	0.196899E-01	0.876923E-04	0.9522E 00	20	0.6847E-01	17	0.	0	5	0	25	0
218	0.197776E-01	0.876923E-04	0.9620E 00	20	0.6809E-01	10	0.	0	5	0	25	0
219	0.198653E-01	0.876923E-04	0.9665E 00	20	0.6804E-01	13	0.	0	5	0	25	0
220	0.199530E-01	0.876923E-04	0.9648E 00	20	0.6809E-01	16	0.	0	5	0	26	0
221	0.200407E-01	0.876923E-04	0.9562E 00	20	0.6812E-01	16	0.	0	5	0	26	0
222	0.201284E-01	0.876923E-04	0.9392E 00	20	0.6806E-01	19	0.	0	5	0	26	0
223	0.202161E-01	0.876923E-04	0.9129E 00	20	0.6843E-01	19	0.	0	5	0	26	0
224	0.203038E-01	0.876923E-04	0.9876E 00	21	0.8629E-01	19	0.	0	5	0	26	0
225	0.204024E-01	0.986538E-04	0.9056E 00	21	0.6840E-01	15	0.	0	5	0	26	0
226	0.204901E-01	0.876923E-04	0.9244E 00	21	0.6851E-01	18	0.	0	5	0	26	0
227	0.205778E-01	0.876923E-04	0.9411E 00	21	0.6857E-01	18	0.	0	5	0	26	0
228	0.206655E-01	0.876923E-04	0.9545E 00	21	0.6827E-01	18	0.	0	5	0	26	0
229	0.207532E-01	0.876923E-04	0.9633E 00	21	0.6768E-01	18	0.	0	5	0	26	0
230	0.208409E-01	0.876923E-04	0.9667E 00	21	0.6786E-01	14	0.	0	5	0	26	0
231	0.209286E-01	0.876923E-04	0.9638E 00	21	0.6825E-01	17	0.	0	5	0	27	0
232	0.210162E-01	0.876923E-04	0.9536E 00	21	0.6839E-01	17	0.	0	5	0	27	0
233	0.211039E-01	0.876923E-04	0.9349E 00	21	0.6829E-01	20	0.	0	5	0	27	0
234	0.211916E-01	0.876923E-04	0.9063E 00	21	0.6852E-01	20	0.	0	5	0	27	0
235	0.212793E-01	0.876923E-04	0.9937E 00	22	0.8624E-01	20	0.	0	5	0	27	0
236	0.213780E-01	0.986538E-04	0.9107E 00	22	0.6794E-01	16	0.	0	5	0	27	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JC	JSTAR	JHAT	IC
237	0.214657E-01	0.876923E-04	0.9288E 00	22	0.6824E-01	19	0.	0	5	0	27	0
238	0.215534E-01	0.876923E-04	0.9446E 00	22	0.6829E-01	19	0.	0	5	0	27	0
239	0.216411E-01	0.876923E-04	0.9571E 00	22	0.6804E-01	19	0.	0	5	0	27	0
240	0.217287E-01	0.876923E-04	0.9645E 00	22	0.6812E-01	15	0.	0	5	0	27	0
241	0.218164E-01	0.876923E-04	0.9665E 00	22	0.6831E-01	15	0.	0	5	0	28	0
242	0.219041E-01	0.876923E-04	0.9619E 00	22	0.6839E-01	18	0.	0	5	0	28	0
243	0.219918E-01	0.876923E-04	0.9496E 00	22	0.6827E-01	18	0.	0	5	0	28	0
244	0.220795E-01	0.876923E-04	0.9286E 00	22	0.6827E-01	21	0.	0	5	0	28	0
245	0.221672E-01	0.876923E-04	0.8973E 00	22	0.6832E-01	21	0.	0	5	0	28	0
246	0.222549E-01	0.876923E-04	0.9992E 00	23	0.8602E-01	17	0.	0	5	0	28	0
247	0.223335E-01	0.786538E-04	0.9149E 00	23	0.6829E-01	17	0.	0	5	0	29	0
248	0.224412E-01	0.876923E-04	0.9321E 00	23	0.6855E-01	20	0.	0	5	0	28	0
249	0.225289E-01	0.876923E-04	0.9471E 00	23	0.6854E-01	20	0.	0	5	0	28	0
250	0.226166E-01	0.876923E-04	0.9584E 00	23	0.6819E-01	20	0.	0	5	0	28	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.19455E 00	8.670E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.19743E 00	8.718E 00	4.435E-03	7.935E 00	5.709E 01	1.013E-01	0.	1.100E-05
2	1.19946E 00	8.697E 00	5.399E-03	6.339E 00	4.561E 01	9.849E-02	6.844E-06	1.100E-05
3	1.20128E 00	8.673E 00	6.071E-03	5.754E 00	4.139E 01	1.005E-01	1.075E-05	1.100E-05
4	1.20301E 00	8.714E 00	6.348E-03	5.527E 00	3.976E 01	1.010E-01	0.	1.100E-05
5	1.20475E 00	8.710E 00	6.329E-03	5.417E 00	3.897E 01	9.865E-02	2.417E-07	1.100E-05
6	1.20643E 00	8.667E 00	6.420E-03	5.418E 00	3.898E 01	1.001E-01	3.584E-05	1.100E-05
7	1.20815E 00	8.701E 00	6.498E-03	5.418E 00	3.898E 01	1.013E-01	0.	1.100E-05
8	1.20987E 00	8.725E 00	6.411E-03	5.362E 00	3.858E 01	9.894E-02	0.	1.100E-05
9	1.21157E 00	8.668E 00	6.462E-03	5.351E 00	3.850E 01	9.951E-02	6.190E-05	1.100E-05
10	1.21324E 00	8.682E 00	6.572E-03	5.366E 00	3.860E 01	1.015E-01	0.	1.100E-05
11	1.21494E 00	8.734E 00	6.485E-03	5.327E 00	3.832E 01	9.941E-02	0.	1.100E-05
12	1.21664E 00	8.682E 00	6.462E-03	5.314E 00	3.823E 01	9.881E-02	5.200E-05	1.100E-05
13	1.21831E 00	8.662E 00	6.584E-03	5.353E 00	3.851E 01	1.014E-01	8.072E-06	1.100E-05
14	1.22000E 00	8.731E 00	6.521E-03	5.333E 00	3.837E 01	1.001E-01	0.	1.100E-05
15	1.22171E 00	8.706E 00	6.445E-03	5.306E 00	3.818E 01	9.841E-02	1.206E-05	1.100E-05
16	1.22338E 00	8.647E 00	6.569E-03	5.346E 00	3.846E 01	1.011E-01	6.920E-05	1.100E-05
17	1.22506E 00	8.717E 00	6.562E-03	5.342E 00	3.843E 01	1.009E-01	0.	1.100E-05
18	1.22677E 00	8.733E 00	6.441E-03	5.300E 00	3.813E 01	9.824E-02	0.	1.100E-05
19	1.22845E 00	8.645E 00	6.541E-03	5.331E 00	3.836E 01	1.004E-01	1.499E-04	1.100E-05
20	1.23011E 00	8.686E 00	6.601E-03	5.348E 00	3.848E 01	1.016E-01	0.	1.100E-05
21	1.23182E 00	8.759E 00	6.452E-03	5.299E 00	3.812E 01	9.837E-02	0.	1.100E-05
22	1.23362E 00	8.064E 00	6.124E-03	5.182E 00	3.728E 01	9.133E-02	8.730E-03	1.100E-05
23	1.23674E 00	5.929E 00	3.519E-03	3.661E 00	2.634E 01	3.707E-02	4.673E-02	1.100E-05
24	1.24227E 00	3.150E 00	1.989E-03	1.561E 00	1.123E 01	8.931E-03	4.508E-02	1.100E-05
25	1.25034E 00	8.497E-01	1.364E-03	3.021E-01	2.173E 00	1.185E-03	2.137E-02	1.100E-05
26	1.26001E 00	3.401E-02	1.138E-03	3.423E-02	2.463E-01	1.121E-04	2.263E-03	1.100E-05
27	1.27000E 00	1.935E-05	1.101E-03	2.931E-02	2.109E-01	9.285E-05	3.814E-06	1.100E-05
28	1.28000E 00	-7.731E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	9.469E-11	1.100E-05
29	1.29000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
30	1.30000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
251	0.227043E-01	0.876923E-04	0.9648E 00	23	0.6781E-01	16	0.	0	5	0	28	0
252	0.227920E-01	0.876923E-04	0.9655E 00	23	0.6789E-01	19	0.	0	5	0	29	0
253	0.228797E-01	0.876923E-04	0.9594E 00	23	0.6813E-01	19	0.	0	5	0	29	0
254	0.229674E-01	0.876923E-04	0.9454E 00	23	0.6809E-01	19	0.	0	5	0	29	0
255	0.230551E-01	0.876923E-04	0.9226E 00	23	0.6837E-01	22	0.	0	5	0	29	0
256	0.231428E-01	0.876923E-04	0.8893E 00	23	0.6833E-01	22	0.	0	5	0	29	0
257	0.232305E-01	0.876923E-04	0.8930E 00	24	0.6821E-01	15	0.	0	5	0	29	0
258	0.233182E-01	0.876923E-04	0.9148E 00	24	0.6825E-01	18	0.	0	5	0	29	0
259	0.234059E-01	0.876923E-04	0.9336E 00	24	0.6840E-01	21	0.	0	5	0	29	0
260	0.234936E-01	0.876923E-04	0.9489E 00	24	0.6828E-01	21	0.	0	5	0	29	0
261	0.235812E-01	0.876923E-04	0.9599E 00	24	0.6787E-01	21	0.	0	5	0	29	0
262	0.236689E-01	0.876922E-04	0.9657E 00	24	0.6800E-01	17	0.	0	5	0	29	0
263	0.237565E-01	0.876922E-04	0.9659E 00	24	0.6832E-01	20	0.	0	5	0	30	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.20486E 00	8.734E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL 1001								
1	1.20734E 00	8.653E 00	4.437E-03	7.936E 00	5.709E 01	1.013E-01	8.659E-05	1.100E-05
2	1.20937E 00	8.731E 00	5.410E-03	6.345E 00	4.564E 01	9.878E-02	0.	1.100E-05
3	1.21119E 00	8.696E 00	6.048E-03	5.745E 00	4.133E 01	9.999E-02	2.243E-05	1.100E-05
4	1.21292E 00	8.660E 00	6.361E-03	5.531E 00	3.979E 01	1.013E-01	2.592E-05	1.100E-05
5	1.21465E 00	8.724E 00	6.349E-03	5.424E 00	3.902E 01	9.909E-02	0.	1.100E-05
6	1.21638E 00	8.709E 00	6.388E-03	5.407E 00	3.890E 01	9.939E-02	4.580E-06	1.100E-05
7	1.21807E 00	8.656E 00	6.501E-03	5.419E 00	3.898E 01	1.014E-01	5.405E-05	1.100E-05
8	1.21974E 00	8.715E 00	6.446E-03	5.374E 00	3.866E 01	9.968E-02	0.	1.100E-05
9	1.22149E 00	8.724E 00	6.430E-03	5.341E 00	3.842E 01	9.882E-02	0.	1.100E-05
10	1.22316E 00	8.656E 00	6.557E-03	5.361E 00	3.857E 01	1.012E-01	9.072E-05	1.100E-05
11	1.22485E 00	8.697E 00	6.535E-03	5.343E 00	3.844E 01	1.005E-01	0.	1.100E-05
12	1.22655E 00	8.737E 00	6.447E-03	5.309E 00	3.819E 01	9.849E-02	0.	1.100E-05
13	1.22823E 00	8.662E 00	6.544E-03	5.340E 00	3.842E 01	1.006E-01	1.105E-04	1.100E-05
14	1.22991E 00	8.675E 00	6.572E-03	5.349E 00	3.849E 01	1.012E-01	0.	1.100E-05
15	1.23161E 00	8.744E 00	6.453E-03	5.309E 00	3.819E 01	9.858E-02	0.	1.100E-05
16	1.23330E 00	8.676E 00	6.505E-03	5.325E 00	3.831E 01	9.968E-02	9.090E-05	1.100E-05
17	1.23497E 00	8.656E 00	6.597E-03	5.353E 00	3.851E 01	1.016E-01	8.225E-06	1.100E-05
18	1.23667E 00	8.742E 00	6.485E-03	5.314E 00	3.823E 01	9.917E-02	0.	1.100E-05
19	1.23837E 00	8.701E 00	6.469E-03	5.308E 00	3.819E 01	9.881E-02	3.224E-05	1.100E-05
20	1.24003E 00	8.638E 00	6.606E-03	5.350E 00	3.849E 01	1.017E-01	7.779E-05	1.100E-05
21	1.24172E 00	8.730E 00	6.531E-03	5.324E 00	3.830E 01	1.001E-01	0.	1.100E-05
22	1.24342E 00	8.725E 00	6.444E-03	5.294E 00	3.809E 01	9.818E-02	5.023E-07	1.100E-05
23	1.24513E 00	8.321E 00	6.443E-03	5.292E 00	3.807E 01	9.812E-02	3.113E-03	1.100E-05
24	1.24790E 00	6.418E 00	3.978E-03	4.047E 00	2.911E 01	4.633E-02	4.198E-02	1.100E-05
25	1.25292E 00	3.677E 00	2.188E-03	1.929E 00	1.388E 01	1.215E-02	4.814E-02	1.100E-05
26	1.26054E 00	1.202E 00	1.443E-03	4.509E-01	3.244E 00	1.873E-03	2.617E-02	1.100E-05
27	1.27002E 00	9.045E-02	1.161E-03	4.370E-02	3.144E-01	1.460E-04	4.357E-03	1.100E-05
28	1.28000E 00	1.349E-04	1.102E-03	2.933E-02	2.110E-01	9.301E-05	2.135E-05	1.100E-05
29	1.29000E 00	-8.334E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	9.576E-11	1.100E-05
30	1.30000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA		JGAM	JO	JSTAR	JHAT	IC
264	0.238443E-01	0.876922E-04	0.9592E 00	23	0.6854E-01	19	0.		0	6	0	29	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.20563E 00	8.712E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.20810E 00	8.674E 00	4.443E-03	7.940E 00	5.712E 01	1.015E-01	1.861E-05	1.100E-05
2	1.21014E 00	8.722E 00	5.399E-03	6.339E 00	4.561E 01	9.850E-02	0.	1.100E-05
3	1.21195E 00	8.686E 00	6.058E-03	5.749E 00	4.136E 01	1.002E-01	2.269E-05	1.100E-05
4	1.21368E 00	8.677E 00	6.364E-03	5.532E 00	3.980E 01	1.013E-01	1.667E-06	1.100E-05
5	1.21541E 00	8.660E 00	6.354E-03	5.426E 00	3.903E 01	9.921E-02	5.502E-06	1.100E-05
6	1.21883E 00	8.729E 00	6.433E-03	5.409E 00	3.891E 01	1.003E-01	0.	2.200E-05
7	1.22054E 00	8.722E 00	6.448E-03	5.375E 00	3.867E 01	9.973E-02	9.388E-07	1.100E-05
8	1.22225E 00	8.704E 00	6.436E-03	5.343E 00	3.844E 01	9.894E-02	5.912E-06	1.100E-05
9	1.22392E 00	8.662E 00	6.572E-03	5.365E 00	3.860E 01	1.015E-01	3.554E-05	1.100E-05
10	1.22561E 00	8.713E 00	6.517E-03	5.338E 00	3.840E 01	1.001E-01	0.	1.100E-05
11	1.22732E 00	8.719E 00	6.444E-03	5.308E 00	3.819E 01	9.844E-02	0.	1.100E-05
12	1.22899E 00	8.658E 00	6.565E-03	5.347E 00	3.847E 01	1.010E-01	7.399E-05	1.100E-05
13	1.23067E 00	8.696E 00	6.559E-03	5.345E 00	3.845E 01	1.009E-01	0.	1.100E-05
14	1.23238E 00	8.735E 00	6.440E-03	5.305E 00	3.816E 01	9.830E-02	0.	1.100E-05
15	1.23406E 00	8.661E 00	6.530E-03	5.333E 00	3.837E 01	1.002E-01	1.063E-04	1.100E-05
16	1.23573E 00	8.675E 00	6.592E-03	5.351E 00	3.850E 01	1.015E-01	0.	1.100E-05
17	1.23743E 00	8.745E 00	6.461E-03	5.307E 00	3.818E 01	9.867E-02	0.	1.100E-05
18	1.23913E 00	8.678E 00	6.492E-03	5.315E 00	3.824E 01	9.929E-02	8.714E-05	1.100E-05
19	1.24079E 00	8.652E 00	6.615E-03	5.353E 00	3.851E 01	1.019E-01	1.306E-05	1.100E-05
20	1.24248E 00	8.745E 00	6.500E-03	5.314E 00	3.823E 01	9.940E-02	0.	1.100E-05
21	1.24419E 00	8.700E 00	6.459E-03	5.299E 00	3.812E 01	9.849E-02	3.836E-05	1.100E-05
22	1.24587E 00	8.424E 00	6.536E-03	5.323E 00	3.829E 01	1.001E-01	1.482E-03	1.100E-05
23	1.24848E 00	6.641E 00	4.217E-03	4.220E 00	3.036E 01	5.121E-02	3.906E-02	1.100E-05
24	1.25327E 00	3.935E 00	2.297E-03	2.116E 00	1.522E 01	1.399E-02	4.925E-02	1.100E-05
25	1.26067E 00	1.389E 00	1.487E-03	5.371E-01	3.864E 00	2.298E-03	2.846E-02	1.100E-05
26	1.27003E 00	1.154E-01	1.175E-03	5.196E-02	3.738E-01	1.757E-04	5.687E-03	1.100E-05
27	1.28000E 00	3.073E-04	1.103E-03	2.934E-02	2.111E-01	9.316E-05	4.391E-05	1.100E-05
28	1.29000E 00	-7.676E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	3.809E-10	1.100E-05
29	1.30000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05
30	1.31000E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.100E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA		JGAM	JO	JSTAR	JHAT	IC
265	0.239320E-01	0.876922E-04	0.9442E 00	23	0.6842E-01	19	0.		0	6	0	29	0
266	0.240157E-01	0.876922E-04	0.9204E 00	23	0.6843E-01	22	0.		0	6	0	29	0
267	0.241074E-01	0.876922E-04	0.9966E 00	23	0.8643E-01	22	0.		0	6	0	29	0
268	0.242061E-01	0.986538E-04	0.9000E 00	24	0.6794E-01	18	0.		0	6	0	29	0
269	0.242937E-01	0.876922E-04	0.9196E 00	24	0.6825E-01	21	0.		0	6	0	29	0
270	0.243814E-01	0.876922E-04	0.9369E 00	24	0.6848E-01	21	0.		0	5	0	29	0
271	0.244691E-01	0.876922E-04	0.9513E 00	24	0.6840E-01	21	0.		0	6	0	29	0
272	0.245568E-01	0.876922E-04	0.9613E 00	24	0.6817E-01	14	0.		0	6	0	29	0
273	0.246445E-01	0.876922E-04	0.9658E 00	24	0.6815E-01	17	0.		0	6	0	29	0
274	0.247322E-01	0.876922E-04	0.9645E 00	24	0.6820E-01	20	0.		0	6	0	30	0
275	0.248199E-01	0.876922E-04	0.9560E 00	23	0.6825E-01	19	0.		0	7	0	29	0
276	0.249076E-01	0.876922E-04	0.9394E 00	23	0.6800E-01	19	0.		0	7	0	29	0
277	0.249953E-01	0.876922E-04	0.9133E 00	23	0.6839E-01	22	0.		0	7	0	29	0
278	0.250000E-01	0.876922E-04	0.5282E-01	23	0.8656E-01	22	0.		0	7	0	29	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
HISTORY EDIT AT CYCLE		278.										
279	0.250987E-01	0.986538E-04	0.9768E 00	24	0.8604E-01	18	0.	0	7	0	29	0
280	0.251973E-01	0.986538E-04	0.9001E 00	24	0.6825E-01	18	0.	0	7	0	29	0
281	0.252850E-01	0.876922E-04	0.9190E 00	24	0.6841E-01	21	0.	0	7	0	29	0
282	0.253727E-01	0.876922E-04	0.9362E 00	24	0.6834E-01	21	0.	0	7	0	29	0
283	0.254604E-01	0.876922E-04	0.9495E 00	24	0.6796E-01	8	0.	0	7	0	29	0
284	0.255482E-01	0.876922E-04	0.9575E 00	24	0.6794E-01	17	0.	0	7	0	29	0
285	0.256358E-01	0.876922E-04	0.9600E 00	24	0.6804E-01	17	0.	0	7	0	30	0
286	0.257235E-01	0.876922E-04	0.9561E 00	23	0.6811E-01	9	0.	0	8	0	29	0
287	0.258112E-01	0.876922E-04	0.9446E 00	23	0.6862E-01	9	0.	0	8	0	29	0
288	0.258989E-01	0.876922E-04	0.9247E 00	23	0.6886E-01	9	0.	0	8	0	29	0
289	0.259865E-01	0.876922E-04	0.8950E 00	23	0.6876E-01	9	0.	0	8	0	29	0
290	0.260742E-01	0.876922E-04	0.9928E 00	24	0.8645E-01	9	0.	0	8	0	29	0
291	0.261729E-01	0.986538E-04	0.9090E 00	24	0.6789E-01	18	0.	0	8	0	29	0
292	0.262606E-01	0.876922E-04	0.9263E 00	24	0.6782E-01	11	0.	0	8	0	29	0
293	0.263483E-01	0.876922E-04	0.9415E 00	24	0.6811E-01	11	0.	0	8	0	29	0
294	0.264360E-01	0.876922E-04	0.9532E 00	24	0.6821E-01	11	0.	0	8	0	29	0
295	0.265237E-01	0.876922E-04	0.9601E 00	24	0.6810E-01	11	0.	0	8	0	29	0
296	0.266113E-01	0.876922E-04	0.9615E 00	24	0.6808E-01	10	0.	0	8	0	30	0
297	0.266990E-01	0.876922E-04	0.9565E 00	23	0.6754E-01	12	0.	0	9	0	29	0
298	0.267867E-01	0.876922E-04	0.9438E 00	23	0.6793E-01	12	0.	0	9	0	29	0
299	0.268744E-01	0.876922E-04	0.9222E 00	23	0.6811E-01	12	0.	0	9	0	29	0
300	0.269621E-01	0.876922E-04	0.8909E 00	23	0.6807E-01	12	0.	0	9	0	29	0
301	0.270498E-01	0.876922E-04	0.8890E 00	24	0.6783E-01	12	0.	0	9	0	29	0
302	0.271375E-01	0.876922E-04	0.9108E 00	24	0.6817E-01	11	0.	0	9	0	29	0
303	0.272252E-01	0.876922E-04	0.9300E 00	24	0.6844E-01	11	0.	0	9	0	29	0
304	0.273129E-01	0.876922E-04	0.9455E 00	24	0.6837E-01	11	0.	0	9	0	29	0
305	0.274006E-01	0.876922E-04	0.9570E 00	24	0.6795E-01	11	0.	0	9	0	29	0
306	0.274883E-01	0.876922E-04	0.9634E 00	24	0.6755E-01	14	0.	0	9	0	29	0
307	0.275760E-01	0.876922E-04	0.9640E 00	24	0.6727E-01	20	0.	0	9	0	30	0
308	0.276636E-01	0.876922E-04	0.9580E 00	23	0.6750E-01	19	0.	0	10	0	29	0
309	0.277513E-01	0.876922E-04	0.9440E 00	23	0.6773E-01	12	0.	0	10	0	29	0
310	0.278390E-01	0.876922E-04	0.9208E 00	23	0.6829E-01	22	0.	0	10	0	29	0
311	0.279267E-01	0.876922E-04	0.9986E 00	23	0.8644E-01	22	0.	0	10	0	29	0
312	0.280254E-01	0.986537E-04	0.9000E 00	24	0.6770E-01	22	0.	0	10	0	29	0
313	0.281131E-01	0.876922E-04	0.9197E 00	24	0.6828E-01	21	0.	0	10	0	29	0
314	0.282008E-01	0.876922E-04	0.9375E 00	24	0.6858E-01	21	0.	0	10	0	29	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.24349E 00	8.636E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.24599E 00	8.723E 00	4.401E-03	7.909E 00	5.690E 01	1.002E-01	0.	1.100E-05
2	1.24801E 00	8.696E 00	5.440E-03	6.358E 00	4.574E 01	9.955E-02	1.191E-05	1.100E-05
3	1.24983E 00	8.720E 00	6.070E-03	5.753E 00	4.139E 01	1.005E-01	0.	1.100E-05
4	1.25156E 00	8.712E 00	6.349E-03	5.527E 00	3.976E 01	1.010E-01	1.267E-06	1.100E-05
5	1.25328E 00	8.670E 00	6.374E-03	5.432E 00	3.908E 01	9.963E-02	3.311E-05	1.100E-05
6	1.25671E 00	8.689E 00	6.426E-03	5.407E 00	3.890E 01	9.998E-02	0.	2.200E-05
7	1.26011E 00	8.685E 00	6.459E-03	5.364E 00	3.859E 01	9.969E-02	2.238E-07	2.200E-05
8	1.26349E 00	8.711E 00	6.510E-03	5.340E 00	3.842E 01	1.000E-01	0.	2.200E-05
9	1.26685E 00	8.673E 00	6.551E-03	5.343E 00	3.844E 01	1.007E-01	2.795E-05	2.200E-05
10	1.27028E 00	8.704E 00	6.424E-03	5.300E 00	3.813E 01	9.798E-02	0.	2.200E-05
11	1.27196E 00	8.681E 00	6.542E-03	5.337E 00	3.840E 01	1.005E-01	9.868E-06	1.100E-05
12	1.27366E 00	8.792E 00	6.480E-03	5.314E 00	3.823E 01	9.909E-02	0.	1.100E-05
13	1.27537E 00	8.788E 00	6.401E-03	5.286E 00	3.803E 01	9.737E-02	2.002E-07	1.100E-05

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
14	1.27706E 00	8.701E 00	6.509E-03	5.320E 00	3.827E 01	9.964E-02	1.480E-04	1.100E-05
15	1.27875E 00	8.739E 00	6.537E-03	5.326E 00	3.832E 01	1.002E-01	0.	1.100E-05
16	1.28046E 00	8.772E 00	6.419E-03	5.287E 00	3.803E 01	9.766E-02	0.	1.100E-05
17	1.28215E 00	8.679E 00	6.495E-03	5.310E 00	3.820E 01	9.924E-02	1.710E-04	1.100E-05
18	1.28383E 00	8.693E 00	6.576E-03	5.335E 00	3.838E 01	1.009E-01	0.	1.100E-05
19	1.28553E 00	8.759E 00	6.462E-03	5.296E 00	3.810E 01	9.850E-02	0.	1.100E-05
20	1.28722E 00	8.684E 00	6.490E-03	5.295E 00	3.809E 01	9.890E-02	1.091E-04	1.100E-05
21	1.28888E 00	8.649E 00	6.636E-03	5.323E 00	3.829E 01	1.016E-01	2.413E-05	1.100E-05
22	1.29057E 00	8.755E 00	6.526E-03	5.296E 00	3.810E 01	9.946E-02	0.	1.100E-05
23	1.29248E 00	7.800E 00	5.762E-03	5.024E 00	3.615E 01	8.330E-02	1.544E-02	1.100E-05
24	1.29591E 00	5.506E 00	3.204E-03	3.311E 00	2.382E 01	3.053E-02	4.914E-02	1.100E-05
25	1.30183E 00	2.736E 00	1.856E-03	1.284E 00	9.237E 00	6.859E-03	4.185E-02	1.100E-05
26	1.31023E 00	6.141E-01	1.311E-03	2.115E-01	1.521E 00	7.977E-04	1.752E-02	1.100E-05
27	1.32008E 00	1.537E-02	1.125E-03	3.116E-02	2.242E-01	1.009E-04	1.207E-03	1.108E-05
28	1.33023E 00	3.353E-06	1.100E-03	2.930E-02	2.108E-01	9.278E-05	7.719E-07	1.117E-05
29	1.34046E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.126E-05
30	1.35078E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.134E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
315	0.282885E-01	0.876922E-04	0.9522E 00	24	0.6855E-01	21	0.	0	10	0	29	0
316	0.283761E-01	0.876922E-04	0.9625E 00	24	0.6819E-01	21	0.	0	10	0	29	0
317	0.284638E-01	0.876922E-04	0.9676E 00	24	0.6757E-01	21	0.	0	10	0	29	0
318	0.285515E-01	0.876922E-04	0.9665E 00	24	0.6803E-01	20	0.	0	10	0	30	0
319	0.286392E-01	0.876922E-04	0.9583E 00	23	0.6828E-01	19	0.	0	11	0	29	0
320	0.287269E-01	0.876922E-04	0.9420E 00	23	0.6822E-01	19	0.	0	11	0	29	0
321	0.288146E-01	0.876922E-04	0.9161E 00	23	0.6865E-01	22	0.	0	11	0	29	0
322	0.289023E-01	0.876922E-04	0.9894E 00	23	0.8668E-01	22	0.	0	11	0	29	0
323	0.290010E-01	0.986537E-04	0.9065E 00	24	0.6818E-01	21	0.	0	11	0	29	0
324	0.290886E-01	0.876922E-04	0.9256E 00	24	0.6864E-01	21	0.	0	11	0	29	0
325	0.291763E-01	0.876922E-04	0.9427E 00	24	0.6880E-01	21	0.	0	11	0	29	0
326	0.292640E-01	0.876922E-04	0.9565E 00	24	0.6862E-01	21	0.	0	11	0	29	0
327	0.293517E-01	0.876922E-04	0.9655E 00	24	0.6817E-01	21	0.	0	11	0	29	0
328	0.294394E-01	0.876922E-04	0.9693E 00	24	0.6841E-01	20	0.	0	11	0	29	0
329	0.295271E-01	0.876922E-04	0.9666E 00	24	0.6882E-01	20	0.	0	11	0	30	0
330	0.296148E-01	0.876922E-04	0.9566E 00	23	0.6891E-01	19	0.	0	12	0	29	0
331	0.297025E-01	0.876922E-04	0.9379E 00	23	0.6876E-01	22	0.	0	12	0	29	0
332	0.297902E-01	0.876922E-04	0.9095E 00	23	0.6901E-01	22	0.	0	12	0	29	0
333	0.298779E-01	0.876922E-04	0.9954E 00	24	0.8689E-01	22	0.	0	12	0	29	0
334	0.299765E-01	0.986537E-04	0.9124E 00	24	0.6877E-01	18	0.	0	12	0	29	0
335	0.300642E-01	0.876922E-04	0.9305E 00	24	0.6885E-01	21	0.	0	12	0	29	0
336	0.301519E-01	0.876922E-04	0.9467E 00	24	0.6892E-01	21	0.	0	12	0	29	0
337	0.302396E-01	0.876922E-04	0.9591E 00	24	0.6867E-01	21	0.	0	12	0	29	0
338	0.303273E-01	0.876922E-04	0.9668E 00	24	0.6858E-01	17	0.	0	12	0	29	0
339	0.304150E-01	0.876922E-04	0.9689E 00	24	0.6880E-01	17	0.	0	12	0	29	0
340	0.305027E-01	0.876922E-04	0.9645E 00	24	0.6891E-01	20	0.	0	12	0	30	0
341	0.305904E-01	0.876922E-04	0.9524E 00	23	0.6893E-01	19	0.	0	13	0	29	0
342	0.306781E-01	0.876922E-04	0.9315E 00	23	0.6886E-01	22	0.	0	13	0	29	0
343	0.307658E-01	0.876922E-04	0.9002E 00	23	0.6896E-01	22	0.	0	13	0	29	0
344	0.308535E-01	0.876922E-04	0.9916E 00	24	0.8750E-01	18	0.	0	13	0	29	0
345	0.309521E-01	0.986537E-04	0.9081E 00	24	0.6935E-01	18	0.	0	13	0	29	0
346	0.310398E-01	0.876922E-04	0.9257E 00	24	0.6932E-01	21	0.	0	13	0	29	0
347	0.311275E-01	0.876922E-04	0.9409E 00	24	0.6929E-01	21	0.	0	13	0	29	0
348	0.312152E-01	0.876922E-04	0.9527E 00	24	0.6894E-01	21	0.	0	13	0	29	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
349	0.313029E-01	0.876922E-04	0.9597E 00	24	0.6899E-01	17	0.	0	13	0	29	0
350	0.313906E-01	0.876922E-04	0.9613E 00	24	0.6911E-01	20	0.	0	13	0	29	0
351	0.314783E-01	0.876922E-04	0.9562E 00	24	0.6937E-01	20	0.	0	13	0	30	0
352	0.315659E-01	0.876922E-04	0.9436E 00	23	0.6931E-01	19	0.	0	14	0	29	0
353	0.316536E-01	0.876922E-04	0.9222E 00	23	0.6893E-01	19	0.	0	14	0	29	0
354	0.317413E-01	0.876922E-04	0.8907E 00	23	0.6882E-01	18	0.	0	14	0	29	0
355	0.318290E-01	0.876922E-04	0.9852E 00	24	0.8761E-01	18	0.	0	14	0	29	0
356	0.319277E-01	0.986537E-04	0.9018E 00	24	0.6934 -01	18	0.	0	14	0	29	0
357	0.320154E-01	0.876922E-04	0.9187E 00	24	0.6935E-01	21	0.	0	14	0	29	0
358	0.321031E-01	0.876922E-04	0.9333E 00	24	0.6927E-01	21	0.	0	14	0	29	0
359	0.321908E-01	0.876922E-04	0.9446E 00	24	0.6887E-01	21	0.	0	14	0	29	0
360	0.322784E-01	0.876922E-04	0.9512E 00	24	0.6913E-01	20	0.	0	14	0	29	0
361	0.323661E-01	0.876922E-04	0.9525E 00	24	0.6952E-01	20	0.	0	14	0	29	0
362	0.324538E-01	0.876922E-04	0.9475E 00	24	0.6960E-01	20	0.	0	14	0	30	0
363	0.325415E-01	0.876922E-04	0.9350E 00	23	0.6935E-01	19	0.	0	15	0	29	0
364	0.326292E-01	0.876922E-04	0.9144E 00	23	0.6882E-01	19	0.	0	15	0	29	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.28159E 00	8.645E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.28449E 00	8.719E 00	4.380E-03	7.894E 00	5.679E 01	9.950E-02	0.	1.100E-05
2	1.28651E 00	8.710E 00	5.459E-03	6.367E 00	4.580E 01	1.000E-01	1.379E-06	1.100E-05
3	1.28833E 00	8.709E 00	6.034E-03	5.739E 00	4.129E 01	9.965E-02	1.882E-08	1.100E-05
4	1.29009E 00	8.740E 00	6.253E-03	5.493E 00	3.952E 01	9.885E-02	0.	1.100E-05
5	1.29181E 00	8.710E 00	6.371E-03	5.431E 00	3.907E 01	9.957E-02	1.747E-05	1.100E-05
6	1.29528E 00	8.749E 00	6.347E-03	5.380E 00	3.871E 01	9.826E-02	0.	2.200E-05
7	1.29870E 00	8.713E 00	6.433E-03	5.355E 00	3.853E 01	9.914E-02	2.480E-05	2.200E-05
8	1.30210E 00	8.712E 00	6.468E-03	5.326E 00	3.832E 01	9.915E-02	2.018E-08	2.200E-05
9	1.30548E 00	8.705E 00	6.510E-03	5.329E 00	3.834E 01	9.985E-02	9.022E-07	2.200E-05
10	1.30885E 00	8.707E 00	6.523E-03	5.332E 00	3.836E 01	1.001E-01	0.	2.200E-05
11	1.31222E 00	8.692E 00	6.545E-03	5.337E 00	3.839E 01	1.005E-01	4.490E-06	2.200E-05
12	1.31562E 00	8.668E 00	6.463E-03	5.306E 00	3.817E 01	9.869E-02	1.177E-05	2.200E-05
13	1.31896E 00	8.715E 00	6.585E-03	5.341E 00	3.843E 01	1.012E-01	[illegible]	2.200E-05
14	1.32231E 00	8.631E 00	6.560E-03	5.330E 00	3.835E 01	1.006E-01	[illegible].374E-04	2.200E-05
15	1.32571E 00	8.662E 00	6.468E-03	5.293E 00	3.808E 01	9.851E-02	[illegible]	2.200E-05
16	1.32738E 00	8.739E 00	6.607E-03	5.313E 00	3.822E 01	1.010E-01	[illegible]	1.100E-05
17	1.32907E 00	8.723E 00	6.498E-03	5.286E 00	3.803E 01	9.884E-02	0.	1.100E-05
18	1.33074E 00	8.643E 00	6.614E-03	5.330E 00	3.834E 01	1.014E-01	1.279E-04	1.100E-05
19	1.33239E 00	8.703E 00	6.649E-03	5.319E 00	3.827E 01	1.018E-01	0.	1.100E-05
20	1.33408E 00	8.760E 00	6.505E-03	5.289E 00	3.805E 01	9.900E-02	0.	1.100E-05
21	1.33576E 00	8.658E 00	6.548E-03	5.326E 00	3.832E 01	1.004E-01	2.037E-04	1.100E-05
22	1.33744E 00	8.582E 00	6.596E-03	5.378E 00	3.869E 01	1.021E-01	1.139E-04	1.108E-05
23	1.33985E 00	7.011E 00	4.630E-03	4.539E 00	3.266E 01	6.049E-02	3.337E-02	1.117E-05
24	1.34439E 00	4.359E 00	2.481E-03	2.455E 00	1.766E 01	1.753E-02	5.100E-02	1.126E-05
25	1.35168E 00	1.700E 00	1.557E-03	6.966E-01	5.012E 00	3.121E-03	3.250E-02	1.134E-05
26	1.36122E 00	1.864E-01	1.198E-03	7.095E-02	5.104E-01	2.445E-04	8.177E-03	1.143E-05
27	1.37164E 00	9.012E-04	1.106E-03	2.939E-02	2.115E-01	9.352E-05	1.141E-04	1.152E-05
28	1.38219E 00	9.100E-09	1.100E-03	2.930E-02	2.108E-01	9.275E-05	2.385E-09	1.161E-05
29	1.39282E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.170E-05
30	1.40353E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.179E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
365	0.327169E-01	0.876922E-04	0.9941E 00	23	0.8700E-01	18	0.	0	15	0	29	0
366	0.328156E-01	0.986537E-04	0.9811E 00	24	0.8736E-01	18	0.	0	15	0	29	0
367	0.329142E-01	0.986537E-04	0.8964E 00	24	0.6910E-01	21	0.	0	15	0	29	0
368	0.330019E-01	0.876922E-04	0.9119E 00	24	0.6925E-01	21	0.	0	15	0	29	0
369	0.330896E-01	0.876922E-04	0.9264E 00	24	0.6907E-01	21	0.	0	15	0	29	0
370	0.331773E-01	0.876922E-04	0.9374E 00	24	0.6858E-01	21	0.	0	15	0	29	0
371	0.332650E-01	0.876922E-04	0.9439E 00	24	0.6875E-01	20	0.	0	15	0	29	0
372	0.333527E-01	0.876922E-04	0.9450E 00	24	0.6907E-01	20	0.	0	15	0	29	0
373	0.334404E-01	0.876922E-04	0.9401E 00	24	0.6910E-01	20	0.	0	15	0	30	0
374	0.335281E-01	0.876922E-04	0.9279E 00	23	0.6882E-01	19	0.	0	16	0	29	0
375	0.336157E-01	0.876922E-04	0.9074E 00	23	0.6827E-01	19	0.	0	16	0	29	0
376	0.337034E-01	0.876922E-04	0.9868E 00	23	0.8680E-01	18	0.	0	16	0	29	0
377	0.338021E-01	0.986537E-04	0.9742E 00	24	0.8706E-01	18	0.	0	16	0	29	0
378	0.339007E-01	0.986537E-04	0.8898E 00	24	0.6858E-01	18	0.	0	16	0	29	0
379	0.339884E-01	0.876922E-04	0.9053E 00	24	0.6806E-01	18	0.	0	16	0	29	0
380	0.340761E-01	0.876922E-04	0.9195E 00	24	0.6741E-01	21	0.	0	16	0	29	0
381	0.341638E-01	0.876921E-04	0.9304E 00	24	0.6759E-01	20	0.	0	16	0	29	0
382	0.342515E-01	0.876921E-04	0.9369E 00	24	0.6815E-01	20	0.	0	16	0	29	0
383	0.343392E-01	0.876921E-04	0.9381E 00	24	0.6846E-01	20	0.	0	16	0	29	0
384	0.344269E-01	0.876921E-04	0.9332E 00	24	0.6847E-01	20	0.	0	16	0	30	0
385	0.345146E-01	0.876921E-04	0.9213E 00	23	0.6818E-01	19	0.	0	17	0	29	0
386	0.346023E-01	0.876921E-04	0.9014E 00	23	0.6761E-01	19	0.	0	17	0	29	0
387	0.346900E-01	0.876921E-04	0.9809E 00	23	0.8585E-01	18	0.	0	17	0	29	0
388	0.347886E-01	0.986537E-04	0.9648E 00	24	0.8652E-01	18	0.	0	17	0	29	0
389	0.348873E-01	0.986537E-04	0.9913E 00	24	0.8673E-01	18	0.	0	17	0	29	0
390	0.349859E-01	0.986537E-04	0.9007E 00	24	0.6826E-01	18	0.	0	17	0	29	0
391	0.350736E-01	0.876921E-04	0.9121E 00	24	0.6765E-01	18	0.	0	17	0	29	0
392	0.351613E-01	0.876921E-04	0.9223E 00	24	0.6676E-01	18	0.	0	17	0	29	0
393	0.352490E-01	0.876921E-04	0.9283E 00	24	0.6620E-01	20	0.	0	17	0	29	0
394	0.353367E-01	0.876921E-04	0.9292E 00	24	0.6658E-01	20	0.	0	17	0	29	0
395	0.354244E-01	0.876921E-04	0.9243E 00	24	0.6671E-01	20	0.	0	17	0	30	0
396	0.355121E-01	0.876921E-04	0.9125E 00	23	0.6711E-01	19	0.	0	18	0	29	0
397	0.355998E-01	0.876921E-04	0.8928E 00	23	0.6713E-01	19	0.	0	18	0	29	0
398	0.356875E-01	0.876921E-04	0.9718E 00	23	0.8447E-01	19	0.	0	18	0	29	0
399	0.357861E-01	0.986537E-04	0.9552E 00	24	0.8354E-01	5	0.	0	18	0	29	0
400	0.358848E-01	0.986537E-04	0.9813E 00	24	0.8322E-01	5	0.	0	18	0	29	0
401	0.359834E-01	0.986537E-04	0.8915E 00	24	0.6551E-01	5	0.	0	18	0	29	0
402	0.360711E-01	0.876921E-04	0.9028E 00	24	0.6533E-01	5	0.	0	18	0	29	0
403	0.361588E-01	0.876921E-04	0.9129E 00	24	0.6534E-01	4	0.	0	18	0	29	0
404	0.362465E-01	0.876921E-04	0.9191E 00	24	0.6552E-01	20	0.	0	18	0	29	0
405	0.363342E-01	0.876921E-04	0.9203E 00	24	0.6563E-01	20	0.	0	18	0	29	0
406	0.364219E-01	0.876921E-04	0.9160E 00	24	0.6546E-01	5	0.	0	18	0	30	0
407	0.365096E-01	0.876921E-04	0.9049E 00	23	0.6571E-01	5	0.	0	19	0	29	0
408	0.365973E-01	0.876921E-04	0.9975E 00	23	0.8355E-01	5	0.	0	19	0	29	0
409	0.366959E-01	0.986536E-04	0.9677E 00	23	0.8401E-01	5	0.	0	19	0	29	0
410	0.367946E-01	0.986536E-04	0.9467E 00	24	0.8442E-01	5	0.	0	19	0	29	0
411	0.368932E-01	0.986536E-04	0.9715E 00	24	0.8475E-01	5	0.	0	19	0	29	0
412	0.369919E-01	0.986536E-04	0.9931E 00	24	0.8494E-01	5	0.	0	19	0	29	0
413	0.370905E-01	0.986536E-04	0.8982E 00	24	0.6715E-01	5	0.	0	19	0	29	0
414	0.371782E-01	0.876921E-04	0.9053E 00	24	0.6708E-01	5	0.	0	19	0	29	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVES	MASS
0	1.32175E 00	8.714E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.32426E 00	8.691E 00	4.384E-03	7.897E 00	5.681E 01	9.963E-02	7.335E-06	1.100E-05
2	1.32627E 00	8.737E 00	5.476E-03	6.374E 00	4.586E 01	1.004E-01	0.	1.100E-05
3	1.32808E 00	8.737E 00	6.065E-03	5.751E 00	4.138E 01	1.004E-01	5.251E-10	1.100E-05
4	1.32981E 00	8.724E 00	6.358E-03	5.530E 00	3.978E 01	1.012E-01	3.015E-06	1.100E-05
5	1.33151E 00	8.732E 00	6.476E-03	5.466E 00	3.933E 01	1.019E-01	0.	1.100E-05
6	1.33491E 00	8.733E 00	6.477E-03	5.424E 00	3.902E 01	1.011E-01	0.	2.200E-05
7	1.33828E 00	8.692E 00	6.528E-03	5.387E 00	3.875E 01	1.012E-01	3.255E-05	2.200E-05
8	1.34164E 00	8.683E 00	6.548E-03	5.353E 00	3.851E 01	1.009E-01	1.475E-06	2.200E-05
9	1.34499E 00	8.688E 00	6.554E-03	5.344E 00	3.844E 01	1.008E-01	0.	2.200E-05
10	1.34837E 00	8.683E 00	6.512E-03	5.329E 00	3.834E 01	9.986E-02	4.422E-07	2.200E-05
11	1.35173E 00	8.682E 00	6.550E-03	5.338E 00	3.840E 01	1.006E-01	1.418E-08	2.200E-05
12	1.35511E 00	8.698E 00	6.512E-03	5.322E 00	3.829E 01	9.974E-02	0.	2.200E-05
13	1.35848E 00	8.697E 00	6.532E-03	5.324E 00	3.830E 01	1.001E-01	5.089E-09	2.200E-05
14	1.36185E 00	8.653E 00	6.525E-03	5.319E 00	3.826E 01	9.987E-02	3.848E-05	2.200E-05
15	1.36520E 00	8.733E 00	6.567E-03	5.325E 00	3.831E 01	1.006E-01	0.	2.200E-05
16	1.36854E 00	8.666E 00	6.594E-03	5.313E 00	3.822E 01	1.008E-01	8.814E-05	2.200E-05
17	1.37192E 00	8.689E 00	6.498E-03	5.281E 00	3.799E 01	9.874E-02	0.	2.200E-05
18	1.37525E 00	8.712E 00	6.609E-03	5.334E 00	3.837E 01	1.014E-01	0.	2.200E-05
19	1.37871E 00	8.694E 00	6.423E-03	5.332E 00	3.836E 01	9.855E-02	6.609E-06	2.225E-05
20	1.38046E 00	8.598E 00	6.432E-03	5.356E 00	3.853E 01	9.914E-02	1.768E-04	1.126E-05
21	1.38221E 00	8.684E 00	6.506E-03	5.386E 00	3.875E 01	1.008E-01	0.	1.134E-05
22	1.38400E 00	8.751E 00	6.388E-03	5.346E 00	3.846E 01	9.827E-02	0.	1.143E-05
23	1.38589E 00	8.070E 00	6.083E-03	5.233E 00	3.764E 01	9.160E-02	8.326E-03	1.152E-05
24	1.38922E 00	5.921E 00	3.484E-03	3.683E 00	2.650E 01	3.693E-02	4.695E-02	1.161E-05
25	1.39517E 00	3.120E 00	1.967E-03	1.550E 00	1.115E 01	8.778E-03	4.534E-02	1.170E-05
26	1.40387E 00	8.180E-01	1.353E-03	2.913E-01	2.096E 00	1.134E-03	2.128E-02	1.179E-05
27	1.41434E 00	3.007E-02	1.135E-03	3.354E-02	2.413E-01	1.095E-04	2.107E-03	1.188E-05
28	1.42521E 00	1.419E-05	1.101E-03	2.931E-02	2.108E-01	9.283E-05	2.953E-06	1.197E-05
29	1.43617E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.206E-05
30	1.44772E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.215E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
415	0.372659E-01	0.876921E-04	0.9114E 00	24	0.6693E-01	5	0.	0	19	0	29	0
416	0.373536E-01	0.876921E-04	0.9126E 00	24	0.6672E-01	5	0.	0	19	0	29	0
417	0.374413E-01	0.876921E-04	0.9082E 00	24	0.6648E-01	5	0.	0	19	0	30	0
418	0.375290E-01	0.876921E-04	0.8974E 00	23	0.6624E-01	5	0.	0	20	0	29	0
419	0.376167E-01	0.876921E-04	0.9890E 00	23	0.8356E-01	5	0.	0	20	0	29	0
420	0.377153E-01	0.986536E-04	0.9597E 00	23	0.8330E-01	5	0.	0	20	0	29	0
421	0.378140E-01	0.986536E-04	0.9395E 00	24	0.8313E-01	5	0.	0	20	0	29	0
422	0.379127E-01	0.986536E-04	0.9639E 00	24	0.8304E-01	5	0.	0	20	0	29	0
423	0.380113E-01	0.986536E-04	0.9851E 00	24	0.8304E-01	5	0.	0	20	0	29	0
424	0.381100E-01	0.986536E-04	0.8909E 00	24	0.6564E-01	5	0.	0	20	0	29	0
425	0.381977E-01	0.876921E-04	0.8978E 00	24	0.6568E-01	5	0.	0	20	0	29	0
426	0.382853E-01	0.876921E-04	0.9037E 00	24	0.6572E-01	5	0.	0	20	0	29	0
427	0.383730E-01	0.876921E-04	0.9051E 00	24	0.6573E-01	5	0.	0	20	0	29	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
428	0.384607E-01	0.876921E-04	0.9010E 00	24	0.6572E-01	5	0.	0	20	0	30	0
429	0.385484E-01	0.876921E-04	0.8907E 00	23	0.6568E-01	5	0.	0	21	0	29	0
430	0.386361E-01	0.876921E-04	0.9870E 00	23	0.8304E-01	5	0.	0	21	0	29	0
431	0.387348E-01	0.986536E-04	0.9614E 00	23	0.8292E-01	5	0.	0	21	0	29	0
432	0.388334E-01	0.986536E-04	0.9321E 00	24	0.8281E-01	5	0.	0	21	0	29	0
433	0.389321E-01	0.986536E-04	0.9574E 00	24	0.8274E-01	5	0.	0	21	0	29	0
434	0.390307E-01	0.986536E-04	0.9798E 00	24	0.8274E-01	5	0.	0	21	0	29	0
435	0.391294E-01	0.986536E-04	0.9978E 00	24	0.8283E-01	5	0.	0	21	0	29	0
436	0.392280E-01	0.986536E-04	0.8983E 00	24	0.6558E-01	5	0.	0	21	0	29	0
437	0.393157E-01	0.876921E-04	0.9007E 00	24	0.6574E-01	5	0.	0	21	0	29	0
438	0.394034E-01	0.876921E-04	0.9014E 00	24	0.6592E-01	5	0.	0	21	0	29	0
439	0.394911E-01	0.876921E-04	0.8962E 00	24	0.6610E-01	5	0.	0	21	0	30	0
440	0.395788E-01	0.876921E-04	0.9157E 00	23	0.5233E-01	5	0.	0	22	0	29	0
441	0.396568E-01	0.779485E-04	0.9077E 00	23	0.6631E-01	5	0.	0	22	0	29	0
442	0.397444E-01	0.876921E-04	0.9559E 00	23	0.8394E-01	5	0.	0	22	0	29	0
443	0.398431E-01	0.986536E-04	0.9354E 00	24	0.8383E-01	5	0.	0	22	0	29	0
444	0.399418E-01	0.986536E-04	0.9509E 00	24	0.8358E-01	5	0.	0	22	0	29	0
445	0.400404E-01	0.986536E-04	0.9648E 00	24	0.8324E-01	5	0.	0	22	0	29	0
446	0.401391E-01	0.986536E-04	0.9764E 00	24	0.8284E-01	5	0.	0	22	0	29	0
447	0.402377E-01	0.986536E-04	0.9849E 00	24	0.8244E-01	5	0.	0	22	0	29	0
448	0.403364E-01	0.986536E-04	0.9894E 00	24	0.8210E-01	5	0.	0	22	0	29	0
449	0.404350E-01	0.986536E-04	0.9886E 00	24	0.8195E-01	4	0.	0	22	0	29	0
450	0.405337E-01	0.986536E-04	0.9812E 00	24	0.8183E-01	4	0.	0	22	0	30	0
451	0.406323E-01	0.986536E-04	0.9658E 00	23	0.8180E-01	4	0.	0	1	0	29	0
452	0.407310E-01	0.986536E-04	0.9409E 00	23	0.8195E-01	4	0.	0	1	0	29	0
453	0.408296E-01	0.986536E-04	0.9047E 00	23	0.8216E-01	4	0.	0	1	0	29	0
454	0.409283E-01	0.986536E-04	0.9125E 00	24	0.8240E-01	4	0.	0	1	0	29	0
455	0.410269E-01	0.986536E-04	0.9346E 00	24	0.8261E-01	4	0.	0	1	0	29	0
456	0.411256E-01	0.986536E-04	0.9538E 00	24	0.8276E-01	4	0.	0	1	0	29	0
457	0.412242E-01	0.986536E-04	0.9692E 00	24	0.8282E-01	4	0.	0	1	0	29	0
458	0.413229E-01	0.986536E-04	0.9802E 00	24	0.8279E-01	4	0.	0	1	0	29	0
459	0.414216E-01	0.986536E-04	0.9860E 00	24	0.8270E-01	4	0.	0	1	0	29	0
460	0.415202E-01	0.986536E-04	0.9856E 00	24	0.8256E-01	4	0.	0	1	0	30	0
461	0.416189E-01	0.986536E-04	0.9779E 00	23	0.8255E-01	3	0.	0	2	0	29	0
462	0.417175E-01	0.986536E-04	0.9617E 00	23	0.8249E-01	3	0.	0	2	0	29	0
463	0.418162E-01	0.986536E-04	0.9358E 00	23	0.8237E-01	3	0.	0	2	0	29	0
464	0.419148E-01	0.986536E-04	0.8985E 00	23	0.8222E-01	3	0.	0	2	0	29	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.36287E 00	8.688E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.36740E 00	8.660E 00	4.855E-03	7.127E 00	5.128E 01	9.958E-02	1.162E-05	2.200E-05
2	1.37098E 00	8.676E 00	6.153E-03	5.620E 00	4.043E 01	9.951E-02	0.	2.200E-05
3	1.37270E 00	8.690E 00	6.390E-03	5.437E 00	3.912E 01	9.998E-02	0.	1.100E-05
4	1.37612E 00	8.685E 00	6.427E-03	5.407E 00	3.890E 01	1.000E-01	3.959E-07	2.200E-05
5	1.37952E 00	8.701E 00	6.471E-03	5.368E 00	3.862E 01	9.996E-02	0.	2.200E-05

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
6	1.38290E 00	8.678E 00	6.513E-03	5.341E 00	3.842E 01	1.001E-01	1.057E-05	2.200E-05
7	1.38626E 00	8.689E 00	6.551E-03	5.343E 00	3.844E 01	1.007E-01	0.	2.200E-05
8	1.38962E 00	8.724E 00	6.531E-03	5.335E 00	3.838E 01	1.003E-01	0.	2.200E-05
9	1.39297E 00	8.739E 00	6.575E-03	5.346E 00	3.846E 01	1.011E-01	0.	2.200E-05
10	1.39631E 00	8.721E 00	6.585E-03	5.346E 00	3.846E 01	1.013E-01	6.597E-06	2.200E-05
11	1.39966E 00	8.734E 00	6.573E-03	5.337E 00	3.840E 01	1.010E-01	0.	2.200E-05
12	1.40302E 00	8.694E 00	6.551E-03	5.327E 00	3.832E 01	1.004E-01	3.171E-05	2.200E-05
13	1.40637E 00	8.703E 00	6.560E-03	5.322E 00	3.829E 01	1.005E-01	0.	2.200E-05
14	1.40972E 00	8.676E 00	6.576E-03	5.307E 00	3.818E 01	1.004E-01	1.507E-05	2.200E-05
15	1.41308E 00	8.681E 00	6.542E-03	5.295E 00	3.810E 01	9.969E-02	0.	2.200E-05
16	1.41639E 00	8.658E 00	6.638E-03	5.343E 00	3.844E 01	1.021E-01	9.682E-06	2.200E-05
17	1.41983E 00	8.657E 00	6.478E-03	5.350E 00	3.849E 01	9.972E-02	4.435E-08	2.225E-05
18	1.42335E 00	8.811E 00	6.424E-03	5.356E 00	3.853E 01	9.902E-02	0.	2.260E-05
19	1.42693E 00	8.638E 00	6.405E-03	5.349E 00	3.848E 01	9.858E-02	5.704E-04	2.295E-05
20	1.43051E 00	8.776E 00	6.499E-03	5.370E 00	3.863E 01	1.004E-01	0.	2.330E-05
21	1.43232E 00	8.623E 00	6.527E-03	5.401E 00	3.886E 01	1.014E-01	4.574E-04	1.179E-05
22	1.43414E 00	8.621E 00	6.514E-03	5.370E 00	3.863E 01	1.007E-01	8.739E-08	1.188E-05
23	1.43655E 00	7.252E 00	4.975E-03	4.712E 00	3.390E 01	6.746E-02	2.722E-02	1.197E-05
24	1.44105E 00	4.709E 00	2.677E-03	2.724E 00	1.960E 01	2.098E-02	5.051E-02	1.206E-05
25	1.44847E 00	2.006E 00	1.639E-03	8.605E-01	6.191E 00	4.057E-03	3.528E-02	1.215E-05
26	1.45845E 00	2.843E-01	1.227E-03	1.003E-01	7.215E-01	3.542E-04	1.082E-02	1.225E-05
27	1.46557E 00	2.405E-03	1.109E-03	2.954E-02	2.125E-01	9.430E-05	2.643E-04	1.234E-05
28	1.48087E 00	6.701E-08	1.100E-03	2.930E-02	2.108E-01	9.275E-05	1.694E-08	1.243E-05
29	1.49227E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.253E-05
30	1.50374E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.263E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	TC
465	0.420135E-01	0.986536E-04	0.9154E 00	24	0.8203E-01	3	0.	0	2	0	29	0
466	0.421121E-01	0.986536E-04	0.9375E 00	24	0.8183E-01	3	0.	0	2	0	29	0
467	0.422108E-01	0.986536E-04	0.9568E 00	24	0.8164E-01	3	0.	0	2	0	29	0
468	0.423094E-01	0.986536E-04	0.9724E 00	24	0.8146E-01	3	0.	0	2	0	29	0
469	0.424081E-01	0.986536E-04	0.9836E 00	24	0.8132E-01	3	0.	0	2	0	29	0
470	0.425067E-01	0.986536E-04	0.9896E 00	24	0.8123E-01	3	0.	0	2	0	29	0
471	0.426054E-01	0.986536E-04	0.9896E 00	24	0.8118E-01	3	0.	0	2	0	30	0
472	0.427040E-01	0.986536E-04	0.9823E 00	23	0.7296E-01	21	0.	0	3	0	29	0
473	0.428027E-01	0.986536E-04	0.9663E 00	23	0.7371E-01	21	0.	0	3	0	29	0
474	0.429014E-01	0.986536E-04	0.9399E 00	23	0.7426E-01	22	0.	0	3	0	29	0
475	0.430000E-01	0.986536E-04	0.9019E 00	23	0.7448E-01	21	0.	0	3	0	29	0
476	0.430987E-01	0.986536E-04	0.9234E 00	24	0.7432E-01	21	0.	0	3	0	29	0
477	0.431973E-01	0.986536E-04	0.9461E 00	24	0.7377E-01	21	0.	0	3	0	29	0
478	0.432960E-01	0.986536E-04	0.9653E 00	24	0.7290E-01	21	0.	0	3	0	29	0
479	0.433946E-01	0.986536E-04	0.9804E 00	24	0.7184E-01	21	0.	0	3	0	29	0
480	0.434933E-01	0.986536E-04	0.9906E 00	24	0.7314E-01	20	0.	0	3	0	29	0
481	0.435919E-01	0.986536E-04	0.9944E 00	24	0.7448E-01	20	0.	0	3	0	29	0
482	0.436906E-01	0.986536E-04	0.9911E 00	24	0.7550E-01	20	0.	0	3	0	30	0
483	0.437892E-01	0.986536E-04	0.9793E 00	23	0.7603E-01	19	0.	0	4	0	29	0
484	0.438879E-01	0.986536E-04	0.9577E 00	23	0.7600E-01	19	0.	0	4	0	29	0
485	0.439865E-01	0.986536E-04	0.9246E 00	23	0.7544E-01	19	0.	0	4	0	29	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JC	JSTAR	JHAT	IC
486	0.440852E-01	0.986536E-04	0.9008E 00	24	0.7447E-01	19	0.	0	4	0	29	0
487	0.441838E-01	0.986536E-04	0.9236E 00	24	0.7328E-01	19	0.	0	4	0	29	0
488	0.442825E-01	0.986536E-04	0.9430E 00	24	0.7263E-01	20	0.	0	4	0	29	0
489	0.443811E-01	0.986536E-04	0.9585E 00	24	0.7361E-01	20	0.	0	4	0	29	0
490	0.444798E-01	0.986536E-04	0.9693E 00	24	0.7432E-01	20	0.	0	4	0	29	0
491	0.445785E-01	0.986536E-04	0.9746E 00	24	0.7466E-01	20	0.	0	4	0	29	0
492	0.446771E-01	0.986536E-04	0.9742E 00	24	0.7457E-01	20	0.	0	4	0	29	0
493	0.447758E-01	0.986536E-04	0.9668E 00	24	0.7409E-01	20	0.	0	4	0	30	0
494	0.448744E-01	0.986536E-04	0.9517E 00	23	0.7328E-01	19	0.	0	5	0	29	0
495	0.449731E-01	0.986536E-04	0.9276E 00	23	0.7280E-01	18	0.	0	5	0	29	0
496	0.450717E-01	0.986536E-04	0.8931E 00	23	0.7382E-01	18	0.	0	5	0	29	0
497	0.451704E-01	0.986536E-04	0.9998E 00	24	0.9444E-01	18	0.	0	5	0	29	0
498	0.452814E-01	0.110985E-03	0.9145E 00	24	0.7507E-01	18	0.	0	5	0	29	0
499	0.453800E-01	0.986536E-04	0.9309E 00	24	0.7497E-01	18	0.	0	5	0	29	0
500	0.454787E-01	0.986536E-04	0.9454E 00	24	0.7441E-01	18	0.	0	5	0	29	0
501	0.455773E-01	0.986536E-04	0.9565E 00	24	0.7347E-01	18	0.	0	5	0	29	0
502	0.456760E-01	0.986536E-04	0.9632E 00	24	0.7231E-01	18	0.	0	5	0	29	0
503	0.457746E-01	0.986536E-04	0.9645E 00	24	0.7167E-01	20	0.	0	5	0	29	0
504	0.458733E-01	0.986536E-04	0.9594E 00	24	0.7215E-01	20	0.	0	5	0	30	0
505	0.459719E-01	0.986536E-04	0.9469E 00	23	0.7266E-01	18	0.	0	6	0	29	0
506	0.460706E-01	0.986536E-04	0.9251E 00	23	0.7320E-01	18	0.	0	6	0	29	0
507	0.461692E-01	0.986536E-04	0.8933E 00	23	0.7341E-01	18	0.	0	6	0	29	0
508	0.462679E-01	0.986536E-04	0.9983E 00	24	0.9274E-01	18	0.	0	6	0	29	0
509	0.463789E-01	0.110985E-03	0.9142E 00	24	0.7273E-01	18	0.	0	6	0	29	0
510	0.464775E-01	0.986536E-04	0.9316E 00	24	0.7284E-01	17	0.	0	6	0	29	0
511	0.465762E-01	0.986536E-04	0.9466E 00	24	0.7419E-01	17	0.	0	6	0	29	0
512	0.466748E-01	0.986536E-04	0.9578E 00	24	0.7532E-01	17	0.	0	6	0	29	0
513	0.467735E-01	0.986536E-04	0.9640E 00	24	0.7605E-01	17	0.	0	6	0	29	0
514	0.468721E-01	0.986536E-04	0.9639E 00	24	0.7625E-01	17	0.	0	6	0	30	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.40594E 00	8.657E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1C01							
1	1.41044E 00	8.672E 00	4.880E-03	7.142E 00	5.138E 01	1.003E-01	9.424E-06	2.200E-05
2	1.41401E 00	8.692E 00	6.176E-03	5.629E 00	4.050E 01	1.000E-01	0.	2.200E-05
3	1.41916E 00	8.699E 00	6.398E-03	5.412E 00	3.893E 01	9.964E-02	0.	3.300E-05
4	1.42594E 00	8.677E 00	6.493E-03	5.355E 00	3.852E 01	1.001E-01	9.343E-06	4.400E-05
5	1.43270E 00	8.662E 00	6.506E-03	5.327E 00	3.833E 01	9.975E-02	4.364E-06	4.400E-05
6	1.43943E 00	8.663E 00	6.537E-03	5.332E 00	3.836E 01	1.003E-01	0.	4.400E-05
7	1.44280E 00	8.724E 00	6.534E-03	5.324E 00	3.831E 01	1.001E-01	0.	2.200E-05
8	1.44619E 00	8.736E 00	6.480E-03	5.304E 00	3.816E 01	9.891E-02	0.	2.200E-05
9	1.44959E 00	8.702E 00	6.472E-03	5.293E 00	3.808E 01	9.858E-02	2.241E-05	2.200E-05
10	1.45293E 00	8.681E 00	6.604E-03	5.316E 00	3.824E 01	1.010E-01	8.857E-06	2.200E-05
11	1.45625E 00	8.716E 00	6.611E-03	5.318E 00	3.826E 01	1.012E-01	0.	2.200E-05
12	1.45959E 00	8.753E 00	6.591E-03	5.328E 00	3.833E 01	1.011E-01	0.	2.200E-05
13	1.46299E 00	8.676E 00	6.557E-03	5.375E 00	3.867E 01	1.014E-01	1.152E-04	2.225E-05
14	1.46644E 00	8.743E 00	6.540E-03	5.394E 00	3.881E 01	1.015E-01	0.	2.260E-05

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
15	1.46558E 00	8.674E 00	6.485E-03	5.375E 00	3.867E 01	1.003E-01	9.180E-05	2.295E-05
16	1.47358E 00	8.709E 00	6.465E-03	5.359E 00	3.855E 01	9.969E-02	0.	2.330E-05
17	1.47537E 00	8.690E 00	6.601E-03	5.424E 00	3.902E 01	1.030E-01	7.631E-06	1.179E-05
18	1.47722E 00	8.714E 00	6.418E-03	5.337E 00	3.839E 01	9.856E-02	0.	1.188E-05
19	1.47908E 00	8.671E 00	6.438E-03	5.321E 00	3.828E 01	9.859E-02	3.451E-05	1.197E-05
20	1.48090E 00	8.648E 00	6.615E-03	5.379E 00	3.870E 01	1.024E-01	1.059E-05	1.206E-05
21	1.48278E 00	8.690E 00	6.464E-03	5.343E 00	3.844E 01	9.938E-02	0.	1.215E-05
22	1.48470E 00	8.729E 00	6.394E-03	5.326E 00	3.832E 01	9.799E-02	0.	1.225E-05
23	1.48662E 00	8.341E 00	6.431E-03	5.346E 00	3.846E 01	9.893E-02	2.876E-03	1.234E-05
24	1.48976E 00	6.423E 00	3.959E-03	4.088E 00	2.941E 01	4.657E-02	4.242E-02	1.243E-05
25	1.49553E 00	3.657E 00	2.170E-03	1.932E 00	1.390E 01	1.207E-02	4.866E-02	1.253E-05
26	1.50434E 00	1.171E 00	1.433E-03	4.419E-01	3.179E 00	1.823E-03	2.622E-02	1.263E-05
27	1.51533E 00	7.338E-02	1.157E-03	4.228E-02	3.042E-01	1.408E-04	4.159E-03	1.272E-05
28	1.52657E 00	1.065E-04	1.102E-03	2.932E-02	2.109E-01	9.297E-05	1.773E-05	1.282E-05
29	1.53871E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.292E-05
30	1.55055E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.302E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
515	0.469708E-01	0.986536E-04	0.9569E 00	23	0.7588E-01	16	0.	0	7	0	29	0
516	0.470694E-01	0.986536E-04	0.9417E 00	23	0.7500E-01	16	0.	0	7	0	29	0
517	0.471681E-01	0.986535E-04	0.9172E 00	23	0.7377E-01	16	0.	0	7	0	29	0
518	0.472668E-01	0.986535E-04	0.9918E 00	23	0.9164E-01	16	0.	0	7	0	29	0
519	0.473777E-01	0.110985E-03	0.9996E 00	24	0.9269E-01	17	0.	0	7	0	29	0
520	0.474887E-01	0.110985E-03	0.9119E 00	24	0.7411E-01	17	0.	0	7	0	29	0
521	0.475874E-01	0.986535E-04	0.9258E 00	24	0.7453E-01	17	0.	0	7	0	29	0
522	0.476860E-01	0.986535E-04	0.9385E 00	24	0.7454E-01	17	0.	0	7	0	29	0
523	0.477847E-01	0.986535E-04	0.9471E 00	24	0.7412E-01	17	0.	0	7	0	29	0
524	0.478833E-01	0.986535E-04	0.9508E 00	24	0.7334E-01	17	0.	0	7	0	29	0
525	0.479820E-01	0.986535E-04	0.9487E 00	24	0.7234E-01	17	0.	0	7	0	30	0
526	0.480806E-01	0.986535E-04	0.9402E 00	23	0.7364E-01	15	0.	0	8	0	29	0
527	0.481793E-01	0.986535E-04	0.9238E 00	23	0.7485E-01	15	0.	0	8	0	29	0
528	0.482779E-01	0.986535E-04	0.8988E 00	23	0.7573E-01	15	0.	0	8	0	29	0
529	0.483766E-01	0.986535E-04	0.9714E 00	23	0.9638E-01	15	0.	0	8	0	29	0
530	0.484876E-01	0.110985E-03	0.9904E 00	24	0.9620E-01	15	0.	0	8	0	29	0
531	0.485986E-01	0.110985E-03	0.9033E 00	24	0.7527E-01	15	0.	0	8	0	29	0
532	0.486972E-01	0.986535E-04	0.9173E 00	24	0.7429E-01	15	0.	0	8	0	29	0
533	0.487959E-01	0.986535E-04	0.9303E 00	24	0.7319E-01	15	0.	0	8	0	29	0
534	0.488945E-01	0.986535E-04	0.9396E 00	24	0.7314E-01	16	0.	0	8	0	29	0
535	0.489932E-01	0.986535E-04	0.9441E 00	24	0.7402E-01	16	0.	0	8	0	29	0
536	0.490918E-01	0.986535E-04	0.9430E 00	24	0.7461E-01	16	0.	0	8	0	30	0
537	0.491905E-01	0.986535E-04	0.9355E 00	23	0.7486E-01	15	0.	0	9	0	29	0
538	0.492891E-01	0.986535E-04	0.9201E 00	23	0.7473E-01	15	0.	0	9	0	29	0
539	0.493878E-01	0.986535E-04	0.8958E 00	23	0.7428E-01	15	0.	0	9	0	29	0
540	0.494865E-01	0.986535E-04	0.9691E 00	23	0.9321E-01	14	0.	0	9	0	29	0
541	0.495974E-01	0.110985E-03	0.9849E 00	24	0.9488E-01	14	0.	0	9	0	29	0
542	0.497084E-01	0.110985E-03	0.8982E 00	24	0.7608E-01	14	0.	0	9	0	29	0
543	0.498071E-01	0.986535E-04	0.9123E 00	24	0.7669E-01	14	0.	0	9	0	29	0
544	0.499057E-01	0.986535E-04	0.9252E 00	24	0.7684E-01	14	0.	0	9	0	29	0
545	0.500000E-01	0.986535E-04	0.8915E 00	24	0.7654E-01	14	0.	0	9	0	29	0

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JC	JSTAR	JHAT	IC
HISTORY EDIT AT CYCLE		545.										
546	0.500987E-01	0.986535E-04	0.9376E 00	24	0.7578E-01	14	0.	0	9	0	29	0
547	0.501973E-01	0.986535E-04	0.9371E 00	24	0.7470E-01	14	0.	0	9	0	30	0
548	0.502960E-01	0.986535E-04	0.9298E 00	23	0.7350E-01	13	0.	0	10	0	29	0
549	0.503946E-01	0.986535E-04	0.9153E 00	23	0.7345E-01	14	0.	0	10	0	29	0
550	0.504933E-01	0.986535E-04	0.8923E 00	23	0.7397E-01	14	0.	0	10	0	29	0
551	0.505919E-01	0.986535E-04	0.9668E 00	23	0.9404E-01	14	0.	0	10	0	29	0
552	0.507029E-01	0.110985E-03	0.9752E 00	24	0.9416E-01	14	0.	0	10	0	29	0
553	0.508139E-01	0.110985E-03	0.8898E 00	24	0.7418E-01	14	0.	0	10	0	29	0
554	0.509125E-01	0.986535E-04	0.9042E 00	24	0.7377E-01	14	0.	0	10	0	29	0
555	0.510112E-01	0.986535E-04	0.9177E 00	24	0.7321E-01	14	0.	0	10	0	29	0
556	0.511098E-01	0.986535E-04	0.9275E 00	24	0.7391E-01	13	0.	0	10	0	29	0
557	0.512085E-01	0.986535E-04	0.9330E 00	24	0.7499E-01	13	0.	0	10	0	29	0
558	0.513072E-01	0.986535E-04	0.9332E 00	24	0.7586E-01	13	0.	0	10	0	30	0
559	0.514058E-01	0.986535E-04	0.9272E 00	23	0.7631E-01	12	0.	0	11	0	29	0
560	0.515045E-01	0.986535E-04	0.9139E 00	23	0.7640E-01	12	0.	0	11	0	29	0
561	0.516031E-01	0.986535E-04	0.8922E 00	23	0.7610E-01	12	0.	0	11	0	29	0
562	0.517018E-01	0.986535E-04	0.9686E 00	23	0.9551E-01	12	0.	0	11	0	29	0
563	0.518128E-01	0.110985E-03	0.9663E 00	24	0.9423E-01	12	0.	0	11	0	29	0
564	0.519237E-01	0.110985E-03	0.9921E 00	24	0.9280E-01	12	0.	0	11	0	29	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.44981E 00	8.660E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL 1001								
1	1.45433E 00	8.672E 00	4.877E-03	7.140E 00	5.137E 01	1.002E-01	0.	2.200E-05
2	1.45789E 00	8.676E 00	6.164E-03	5.624E 00	4.046E 01	9.977E-02	0.	2.700E-05
3	1.46302E 00	8.697E 00	6.436E-03	5.424E 00	3.902E 01	1.005E-01	0.	3.300E-05
4	1.46981E 00	8.708E 00	6.482E-[illegible]	5.351E 00	3.850E 01	9.981E-02	0.	4.400E-05
5	1.47660E 00	8.684E 00	6.480E-03	5.319E 00	3.826E 01	9.919E-02	1.085E-05	4.400E-05
6	1.48331E 00	8.674E 00	6.561E-03	5.340E 00	3.841E 01	1.008E-01	2.328E-06	4.400E-05
7	1.49006E 00	8.691E 00	6.520E-03	5.318E 00	3.826E 01	9.978E-02	0.	4.400E-05
8	1.49677E 00	8.673E 00	6.550E-03	5.309E 00	3.819E 01	1.001E-01	6.078E-06	4.400E-05
9	1.50353E 00	8.661E 00	6.514E-03	5.294E 00	3.809E 01	9.924E-02	2.728E-06	4.400E-05
10	1.51046E 00	8.689E 00	6.468E-03	5.359E 00	3.855E 01	9.974E-02	0.	4.485E-05
11	1.51759E 00	8.691E 00	6.484E-03	5.370E 00	3.863E 01	1.002E-01	0.	4.675E-05
12	1.51941E 00	8.796E 00	6.495E-03	5.387E 00	3.876E 01	1.007E-01	0.	1.179E-05
13	1.52122E 00	8.731E 00	6.541E-03	5.377E 00	3.868E 01	1.012E-01	8.100E-05	1.188E-05
14	1.52304E 00	8.630E 00	6.577E-03	5.366E 00	3.861E 01	1.016E-01	2.005E-04	1.197E-05
15	1.52489E 00	8.750E 00	6.534E-03	5.351E 00	3.850E 01	1.006E-01	0.	1.206E-05
16	1.52676E 00	8.737E 00	6.511E-03	5.358E 00	3.855E 01	1.004E-01	0.	1.215E-05
17	1.52862E 00	8.670E 00	6.559E-03	5.379E 00	3.870E 01	1.015E-01	2.682E-04	1.225E-05
18	1.53050E 00	8.701E 00	6.570E-03	5.391E 00	3.878E 01	1.019E-01	0.	1.234E-05
19	1.53241E 00	8.797E 00	6.515E-03	5.376E 00	3.868E 01	1.008E-01	0.	1.243E-05
20	1.53435E 00	8.676E 00	6.469E-03	5.356E 00	3.853E 01	9.970E-02	2.855E-04	1.253E-05
21	1.53627E 00	8.632E 00	6.549E-03	5.380E 00	3.870E 01	1.014E-01	3.805E-05	1.263E-05
22	1.53823E 00	8.753E 00	6.508E-03	5.368E 00	3.862E 01	1.005E-01	0.	1.272E-05
23	1.54056E 00	7.642E 00	5.493E-03	4.986E 00	3.587E 01	7.881E-02	1.984E-02	1.282E-05
24	1.54491E 00	5.213E 00	2.971 -03	3.129E 00	2.251E 01	2.676E-02	5.102E-02	1.292E-05
25	1.55233E 00	2.431E 00	1.75[illegible]-03	1.115E 00	8.018E 00	5.628E-03	3.989E-02	1.302E-05
26	1.56266E 00	4.522E-01	1.270E-03	1.566E-01	1.127E 00	5.727E-04	1.477E-02	1.312E-05
27	1.57450E 00	7.208E-03	1.117E-03	3.009E-02	2.164E-01	9.668E-05	6.618E-04	1.322E-05
28	1.58661E 00	6.068E-07	1.100E-03	2.930E-02	2.108E-01	9.276E-05	1.671E-07	1.332E-05
29	1.59881E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.342E-05
30	1.61111E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.353E-05

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
565	0.520347E-01	0.110985E-03	0.9006E 00	24	0.7378E-01	13	0.	0	11	0	29	0
566	0.521334E-01	0.986535E-04	0.9111E 00	24	0.7427E-01	13	0.	0	11	0	29	0
567	0.522320E-01	0.986535E-04	0.9203E 00	24	0.7458E-01	13	0.	0	11	0	29	0
568	0.523307E-01	0.986535E-04	0.9250E 00	24	0.7463E-01	13	0.	0	11	0	29	0
569	0.524293E-01	0.986535E-04	0.9247E 00	24	0.7440E-01	13	0.	0	11	0	29	0
570	0.525280E-01	0.986535E-04	0.9182E 00	23	0.7278E-01	13	0.	0	12	0	30	0
571	0.526266E-01	0.986535E-04	0.9047E 00	23	0.7177E-01	13	0.	0	12	0	29	0
572	0.527253E-01	0.986535E-04	0.9939E 00	23	0.9038E-01	14	0.	0	12	0	29	0
573	0.528363E-01	0.110985E-03	0.9598E 00	23	0.9165E-01	14	0.	0	12	0	29	0
574	0.529473E-01	0.110985E-03	0.9583E 00	24	0.9246E-01	14	0.	0	12	0	29	0
575	0.530582E-01	0.110985E-03	0.9824E 00	24	0.9263E-01	14	0.	0	12	0	29	0
576	0.531692E-01	0.110985E-03	0.8915E 00	24	0.7280E-01	14	0.	0	12	0	29	0
577	0.532679E-01	0.986535E-04	0.9020E 00	24	0.7209E-01	14	0.	0	12	0	29	0
578	0.533665E-01	0.986535E-04	0.9112E 00	24	0.7117E-01	13	0.	0	12	0	29	0
579	0.534652E-01	0.986535E-04	0.9168E 00	24	0.7209E-01	13	0.	0	12	0	29	0
580	0.535638E-01	0.986535E-04	0.9172E 00	24	0.7286E-01	13	0.	0	12	0	30	0
581	0.536625E-01	0.986535E-04	0.9124E 00	23	0.7036E-01	15	0.	0	13	0	29	0
582	0.537612E-01	0.986535E-04	0.9007E 00	23	0.7096E-01	15	0.	0	13	0	29	0
583	0.538598E-01	0.986535E-04	0.9916E 00	23	0.9007E-01	15	0.	0	13	0	29	0
584	0.539708E-01	0.110985E-03	0.9611E 00	23	0.8977E-01	15	0.	0	13	0	29	0
585	0.540818E-01	0.110985E-03	0.9512E 00	24	0.8891E-01	15	0.	0	13	0	29	0
586	0.541928E-01	0.110985E-03	0.9760E 00	24	0.8921E-01	14	0.	0	13	0	29	0
587	0.543037E-01	0.110985E-03	0.9977E 00	24	0.8969E-01	14	0.	0	13	0	29	0
588	0.544147E-01	0.110985E-03	0.9023E 00	24	0.7091E-01	14	0.	0	13	0	29	0
589	0.545134E-01	0.986535E-04	0.9095E 00	24	0.7060E-01	14	0.	0	13	0	29	0
590	0.546120E-01	0.986535E-04	0.9152E 00	24	0.6995E-01	14	0.	0	13	0	29	0
591	0.547107E-01	0.986535E-04	0.9159E 00	24	0.6904E-01	14	0.	0	13	0	30	0
592	0.548093E-01	0.986535E-04	0.9109E 00	23	0.6839E-01	15	0.	0	14	0	29	0
593	0.549080E-01	0.986535E-04	0.8990E 00	23	0.6880E-01	15	0.	0	14	0	29	0
594	0.550066E-01	0.986535E-04	0.9891E 00	23	0.8739E-01	15	0.	0	14	0	29	0
595	0.551176E-01	0.110985E-03	0.9573E 00	23	0.8736E-01	15	0.	0	14	0	29	0
596	0.552286E-01	0.110985E-03	0.9470E 00	24	0.8683E-01	15	0.	0	14	0	29	0
597	0.553396E-01	0.110985E-03	0.9712E 00	24	0.8581E-01	15	0.	0	14	0	29	0
598	0.554505E-01	0.110985E-03	0.9920E 00	24	0.8481E-01	17	0.	0	14	0	29	0
599	0.555616E-01	0.110985E-03	0.8962E 00	24	0.6731E-01	17	0.	0	14	0	29	0
600	0.556602E-01	0.986535E-04	0.9024E 00	24	0.6733E-01	17	0.	0	14	0	29	0
601	0.557589E-01	0.986535E-04	0.9073E 00	24	0.6712E-01	17	0.	0	14	0	29	0
602	0.558575E-01	0.986535E-04	0.9074E 00	24	0.6670E-01	17	0.	0	14	0	30	0
603	0.559562E-01	0.986535E-04	0.9015E 00	23	0.6639E-01	16	0.	0	15	0	29	0
604	0.560548E-01	0.986535E-04	0.8895E 00	23	0.6584E-01	16	0.	0	15	0	29	0
605	0.561535E-01	0.986535E-04	0.9788E 00	23	0.8260E-01	18	0.	0	15	0	29	0
606	0.562645E-01	0.110985E-03	0.9477E 00	23	0.8327E-01	18	0.	0	15	0	29	0
607	0.563755E-01	0.110985E-03	0.9366E 00	24	0.8342E-01	18	0.	0	15	0	29	0
608	0.564864E-01	0.110985E-03	0.9604E 00	24	0.8304E-01	18	0.	0	15	0	29	0
609	0.565974E-01	0.110985E-03	0.9808E 00	24	0.8221E-01	18	0.	0	15	0	29	0
610	0.567084E-01	0.110985E-03	0.9972E 00	24	0.8210E-01	17	0.	0	15	0	29	0
611	0.568194E-01	0.110985E-03	0.8965E 00	24	0.6482E-01	17	0.	0	15	0	29	0
612	0.569181E-01	0.986535E-04	0.8982E 00	24	0.6446E-01	17	0.	0	15	0	29	0
613	0.570167E-01	0.986535E-04	0.8986E 00	24	0.6384E-01	17	0.	0	15	0	30	0
614	0.571154E-01	0.986535E-04	0.8933E 00	23	0.6387E-01	19	0.	0	16	0	29	0

J	RADIUS	VELOCITY	DENSITY	TEMP	INTENG	PRESSURE	ARTVIS	MASS
0	1.49495E 00	8.690E 00	0.	0.	0.	1.000E-01	0.	0.
MATERIAL	1001							
1	1.49946E 00	8.709E 00	4.872E-03	7.137E 00	5.134E 01	1.001E-01	0.	2.200E-05
2	1.50300E 00	8.694E 00	6.218E-03	5.644E 00	4.060E 01	1.010E-01	4.003E-06	2.200E-05
3	1.50812E 00	8.674E 00	6.446E-03	5.428E 00	3.905E 01	1.007E-01	7.686E-06	3.300E-05
4	1.51439E 00	8.686E 00	6.498E-03	5.357E 00	3.854E 01	1.002E-01	0.	4.400E-05
5	1.52168E 00	8.676E 00	6.480E-03	5.319E 00	3.826E 01	9.918E-02	1.932E-06	4.400E-05
6	1.52841E 00	8.693E 00	6.544E-03	5.334E 00	3.838E 01	1.005E-01	0.	4.400E-05
7	1.53515E 00	8.683E 00	6.524E-03	5.320E 00	3.827E 01	9.987E-02	2.065E-06	4.400E-05
8	1.54186E 00	8.691E 00	6.555E-03	5.310E 00	3.820E 01	1.002E-01	0.	4.400E-05
9	1.54859E 00	8.681E 00	6.544E-03	5.304E 00	3.816E 01	9.987E-02	2.132E-06	4.400E-05
10	1.55550E 00	8.698E 00	6.488E-03	5.365E 00	3.860E 01	1.002E-01	0.	4.485E-05
11	1.56265E 00	8.676E 00	6.464E-03	5.363E 00	3.858E 01	9.976E-02	9.953E-06	4.625E-05
12	1.56631E 00	8.663E 00	6.471E-03	5.367E 00	3.861E 01	9.994E-02	3.051E-06	2.366E-05
13	1.57003E 00	8.655E 00	6.459E-03	5.327E 00	3.832E 01	9.902E-02	1.337E-06	2.403E-05
14	1.57379E 00	8.702E 00	6.482E-03	5.351E 00	3.849E 01	9.981E-02	0.	2.440E-05
15	1.57763E 00	8.619E 00	6.467E-03	5.358E 00	3.855E 01	9.971E-02	1.323E-04	2.477E-05
16	1.58153E 00	8.703E 00	6.443E-03	5.345E 00	3.846E 01	9.912E-02	0.	2.516E-05
17	1.58351E 00	8.760E 00	6.427E-03	5.340E 00	3.842E 01	9.877E-02	0.	1.272E-05
18	1.58548E 00	8.720E 00	6.515E-03	5.375E 00	3.867E 01	1.008E-01	3.152E-05	1.232E-05
19	1.58743E 00	8.683E 00	6.628E-03	5.417E 00	3.897E 01	1.033E-01	2.787E-05	1.292E-05
20	1.58944E 00	8.773E 00	6.464E-03	5.370E 00	3.863E 01	9.989E-02	0.	1.302E-05
21	1.59148E 00	8.727E 00	6.430E-03	5.371E 00	3.864E 01	9.938E-02	4.010E-05	1.312E-05
22	1.59352E 00	8.456E 00	6.494E-03	5.403E 00	3.887E 01	1.010E-01	1.426E-03	1.322E-05
23	1.59672E 00	6.643E 00	4.160E-03	4.269E 00	3.071E 01	5.110E-02	3.988E-02	1.332E-05
24	1.60266E 00	3.900E 00	2.260E-03	2.109E 00	1.517E 01	1.372E-02	4.989E-02	1.342E-05
25	1.61187E 00	1.340E 00	1.469E-03	5.183E-01	3.729E 00	2.191E-03	2.849E-02	1.353E-05
26	1.62354E 00	1.023E-01	1.168E-03	4.873E-02	3.506E-01	1.639E-04	5.343E-03	1.363E-05
27	1.63599E 00	2.271E-04	1.103E-03	2.933E-02	2.110E-01	9.308E-05	3.447E-05	1.374E-05
28	1.64858E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	7.519E-11	1.384E-05
29	1.66126E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.395E-05
30	1.67404E 00	0.	1.100E-03	2.930E-02	2.108E-01	9.275E-05	0.	1.406E-05

```
7044 ACCOUNTING SUMMARY       02/20/67       SEQ. NO. 0600

IBJOB

   FORTRAN IV             00 HR       01 MIN      41 SEC

   LOADING                00 HR       02 MIN      41 SEC

   EXECUTION              00 HR       00 MIN      58 SEC

IBSYS JOB SUPERVISION     00 HR       02 MIN      12 SEC

TOTAL TIME                00 HR       07 MIN      34 SEC

$IBSYS

$CLOSE         S.SU07.REWIND

$CLOSE         S.SU09.REWIND

$CLOSE         S.SU10.REWIND

$IBSYS         ENDJOB         TOTAL NUMBER OF CARDS IN YOUR INPUT DECK  001665
```

IV. RADIATION EXAMPLE

A somewhat more complex example may help to demonstrate the radiation aspects of the program. This second example will use spherical symmetry, radiation diffusion by the implicit formulation, single precision, analytic equations of state and opacities, two materials, grey-body radiation loss, and a different choice of output variables and units.

The physical situation chosen to demonstrate the interplay of radiation and hydrodynamics is that of air surrounding an aluminum sphere in which 10^{12} calories are released. This energy source is confined to the innermost one-fifth of the aluminum mass and is introduced uniformly in time over one-tenth of a microsecond. The mass of aluminum is taken as 100 pounds. Although this suddenly heated metal ball is not clearly a good model for an exploding nuclear device, it will serve well here to illustrate the essential features of the program in dealing with transient radiation flow problems where hydrodynamics also becomes important.

The air and the aluminum are characterized by analytic formulae for the equations of state and opacities and are presented in the listings at the end of this section. The analytic forms for air are particularly complex, and can lead to excessive running time for some problems, since the equations are computed through many hundreds of times for most cycles. The alternatives are to use simpler approximate fits (this one is good to 5% almost everywhere) or to use tabular forms. The formulae for aluminum used here are quite approximate but also fairly simple.

The CDR subroutine computes sources and sinks. In this example, it generates the initial energy (at a constant rate for a fixed time interval), and also calculates a grey-body radiation loss in the air which (by choosing an input option of IRAD=7 or 4) is computed using a special fit to the emissivity of air. A choice of IRAD=6 or 3 allows the subroutine to calculate this grey-body loss with the Rosseland mean free path of whatever material is exposed. This grey-body loss has the form

$$D = \sigma R^{(\delta-1)} T^4 (\Delta t)(\Delta R/\lambda)/(\Delta m), \tag{74}$$

in which σ is the Sefan-Boltzman radiation constant, here equal to 5.67×10^{-4} jerks/meter^2/millisecond/10^4 degrees Kelvin, and λ is either the Rosseland mean free path or the emission mean free path for air. ΔR is the zone thickness, $R_j - R_{j-1}$ for the corresponding mass $\Delta m_{j-\frac{1}{2}}$. There is a further multiplicative factor when air is the outer region (IRAD = 4 or 7) which is an approximation to the cold air transmission cutoff in the ultraviolet (at 1860 Angstroms). In units of the code (temperature T in 10^4 degrees Kelvin) this factor is:

$$f = 25/(25 + 3.5xT^2 + T^3). \tag{75}$$

The Generate print-out is similar to that for the first example, but now it is necessary to include a radiation stability constant. The implicit scheme in theory needs no limit on time step size, but some limit is necessary in practice both to avoid too many iterations per cycle and to avoid exceeding convergence domains which frequently seem to stem from the complexities of the equation of state fits. While the radiation front is building or when it is crossing a discontinuous boundary (between regions), it is prudent to limit the stability constant C5 to a value of about 1.5, but afterwards a much larger value is more economical. While too large a value necessitates too many iterations per cycle, too small a value restricts the size of the time increment without much reduction in number of iterations. The total number of passes through the iteration loop in advancing a given amount in problem time is a rough measure of running time economy, since the bulk of the computing, particularly with complex equations of state, is done in such loops (e.g., ROC, RDI, ROD loop).

The iteration procedure for convergence is arranged to become progressively less exacting as the number of iterations increases.

After five iterations the test on the fractional change of luminosities is dropped and only temperature changes are monitored for subsequent iterations. (See listing or flow diagram for the RDI subroutine.) After ten iterations, the fractional change of temperature is allowed to be four times larger (where initially $\delta T/T$ is tested against X3, now the test is against 4*X3). After 15 iterations the test is made against 20*X3, after 20 iterations against 100*X3, and after 25 times around the loop, the test on the iterative change in temperature relative to the temperature itself is that it be less than 1000*X3. At the twenty-fifth iteration a trouble-shooting print routine is activated, and most of the numerical values for parameters calculated in the relaxation loop are listed for all subsequent iterations until relaxation or until the 29th loop when the problem dies.

Settling for less accuracy when many iterations are required in finding a self-consistent set of temperatures and luminosities implies that the procedure is to some extent self correcting, and that subsequent cycles will not suffer from such a single or occasional reduction in accuracy. When a real instablity is in the making, such is not the case, but then, a cycle or two later, a stop is inevitable.

All of the test constants, X1 through X6, must be specified for this test case with radiation and with added zones. The X1 test occurs in the ROE subroutine in finding new temperatures in the hydrodynamic regions beyond the radiation diffusion region and is similar to the GETVAR routine which uses X4. Both X1 and X4 should be taken to have the smallest values ($2\text{x}10^{-6}$) of any of the test constants. Both require that temperatures derived for some value of energy and density will be correct (consistent) to two parts in a million. The X2 test occurs in the implicit iteration loop for luminosity convergence, and is taken here to be four times larger than X1 and X4. The X3 test determines the temperature convergence in the same implicit scheme, but is chosen here to have a value twice that of X1 or X4. The test of convergence in the first guess for temperatures and luminosities prior to entering the implicit iterative loop uses X6 and as such is allowed to be 100 times larger

than X1. The X5 constant controls the size of the doubled zones. If a pair of zones about to be merged into a single zone (CZR subroutine) promises to be thicker than X5 times the largest radius active in the problem (radius at JHAT), then that doubling is not allowed. With a value of 0.1, no zone will be allowed, through doubling of zones, to become larger than 10% of the maximum radius.

In the RAND version (but not the all-FORTRAN version), a set of variables and the units in which they will be presented are listed at the beginning of the output. The zero-cycle listing which follows shows the initial conditions to include no motion, normal 293 degree Kelvin (20^{o}C) temperature, 14.63 psi ambient pressure in the air (something more than 2 kilobars in the aluminum initially), 1.2 kilograms per cubic meter air density, etc. INTENG stands for internal energy, DYNPRS for dynamic pressure ($\rho u^2/2$), ARTVIS for artificial viscosity, LMNSTY for luminosity, ROSMFP for Rosseland mean free path, NETPWR for net power as represented by the mean free path times the spacial gradient of luminosity ($\lambda \cdot (L_j - L_{j-1})/(R_j - R_{j-1})$), and RALORT for radiation loss rate as carried by half the THETA term or as D*ΔM.

Note that on the first cycle, although the stability numbers are all small, convergence requires three iterations as indicated by iteration counter (IC).

Note that the energy check print-out after the first cycle shows some internal energy in the first region, indicating that the source term is active. The slight amount of kinetic energy in both regions stems from the small velocity that arises at the region interface (pressure in the aluminum being initially 35,360 psi).

The first cycle print-out shows the velocity at the interface, the corresponding dynamic pressures, the rise in the temperature, internal energy, and pressure in the first zone where the energy is being introduced as well as changes in luminosity, mean free path and net power. In the first zone, the radiation loss rate shows a negative value (-10^{19} cal/sec), which is the rate of input of source energy. Some slight radiation loss occurs at the interface also, but is unrealistic and negligible.

The next two cycles show the radiation flowing into the second zone as the source continues, and the energy increases. These consecutive cycle listings do not provide adequate data for easy code checking, since each cycle has several iteration loops within it. In the RDI subroutine, however, is a call for printing of much of the iterative loop function values, and it can be altered to print on every pass. (It is ordinarily set to print only after 25 iterations, to help in diagnosing a failure to converge.)

By the fourth cycle the number of iterations has risen to 7, but the stability conditions (LAMBDA, OMEGA, and GAMMA) are all less than unity, so the Δt is still allowed to increase. By the eleventh cycle, the radiation stability measure ($GAMMA_0$ with C5 = 1.5) has risen so that the next cycle must be at a smaller time increment. At this same time, the radiation has heated the fourth zone enough to include it in the radiation diffusion cycle (JSTAR increases from 3 to 4). As more and more energy is injected into the first zone, the temperatures rise, and the luminosities increase.

Although some compression is generated in the second zone by the high pressure in the first zone, and rather high velocities result (about 2000 ft/sec) in the first zone after the second cycle, the time is still too short for a change in the density to show up in the first four figures listed. On the first cycle print-out, small artificial viscosity pressures show up in all the aluminum zones. These are spurious, and are due to the slight difference in round-off between the densities as calculated in the generator and as computed here in the hydrodynamic subroutine (HYD). These viscosity terms in turn lead to the small velocities of cycle 2 for the same aluminum zones, although the first and last aluminum zones have larger velocities due to the pressure gradients between the heated first zones and the second zone and between the aluminum and air.

By the third cycle, slightly more than 5% of the energy has been injected, and it is still residing in the first zone of aluminum. The energy check sums (labeled E, K, W, Y, W-Y+Y) after cycle 3 show this clearly. They also show that no energy has been radiated from

aluminum to air or out of the air as yet (the Y terms being still negligible), nor has any net work been done on the air (W-Y+Y for region 2). The net work on region one is just the energy introduced into the aluminum.

By cycle 10, somewhat more than a third of the total energy to be introduced is now in the aluminum ("none" yet in the air). The time steps have been allowed to increase to nearly three times the original choice. However, the GAMMA term is growing rapidly as the radiation begins to flow, and by the 12th cycle it forces the Δt to decrease. A careful look at the output for cycle 10 will reveal the beginning of some rapid changes, for which smaller time steps are perhaps desirable. The innermost aluminum zone has a temperature of more than 15 million degrees, the velocity is more than 10^5 ft/sec, the densities are beginning to change, the pressure is high and the luminosity is rising. The Rosseland mean free path is larger, and the net power flux is approaching a few percent of the rate of introduction of energy. Essentially nothing is going on in the air, as yet.

By the thirtieth cycle, the time step (DT) has dropped again to what it started as. All the energy has just been put in by the source term, and on the next and succeeding cycles no more energy will be pumped into the first zone. Since the time did not quite reach 10^{-4} on the thirtieth cycle, but will exceed that value on the next cycle, not quite all the intended energy was introduced - lacking about ½%.* A little energy is now leaking out into the air by radiation diffusion ($Y \simeq 1.3\%$) and a little hydrodynamic work has been done on the air (W-Y+Y = 0.814342E-03). The outside of the aluminum sphere is just getting up to high velocity, and is still moving at about half of the velocity of the hot interior. None of the air is compressed, but the first air zone is already up to a tenth of a million degrees.

In the next thirty cycles the time advances to .159511 microseconds, and some eighteen percent of the energy flows into the air by radiation diffusion. This is shown by the energy check Y term for region 1 at cycle 60 (Y = .185566). Essentially all of this energy is in heat and shows as internal energy in air (E = 0.185538), with the corresponding kinetic energy for air (K = 0.0315925) being derived

*Recall that the source was chosen as a fixed rate (~10^{19} cal/sec for 10^{-7} sec), so that the exact energy could have been injected by fixing the time step or by calling for an output at that time.

from the work done by the expanding aluminum. The work term for air corresponds: W-Y+Y = 0.0315648.

The cycle 60 output shows that the aluminum temperatures have fallen, and the luminosities and mean free paths are also decreasing. At the same time, the velocities are increasing. The air is now hot out to about seven feet, and so a "fireball" has appeared.

At cycle 103 a special print occurs as directed by the GETVAR subroutine. Whenever the iteration count in the convergence loop which derives a temperature from a new internal energy exceeds 10, the print occurs, listing the zone number (16 in this case), the iteration count, the variables (OVAR and VAR, in this case since NV is 2, OVAR is the temperature and VAR is the specific volume), the function being worked with FN (in this case the energy, since MF = 2), and the desired final value for the function F.

When large changes in variables are taking place, the combined use of complicated equation of state functions and the Newton's Method may lead to trouble. The Newton's Method employs local slopes (derivatives) to approximate the change needed in the variable in order to arrive at the correct function value. Occasionally, as has happened here, a pair of points on the functional curve are struck such that the slopes from each return the variable to the previous value on the next step, i.e., the oscillation between two values is stable, and convergence is never achieved. To avoid such a needless catastrophe, the GETVAR subroutine kicks the convergence loop just once on the 16th iteration by taking the next guess as the average of the current and the previous guess. As is evident in this case, such a joggle can quickly lead to convergence.

The termination of the run at cycle 131 represents 10 minutes of execution. The next run was chosen to have C5 = 10, which allows a substantial increase in the time steps since the radiation diffusion stability (using C5) has been restricting the time steps. After regenerating with this change, the time steps increase (by 9/8ths) every cycle for twenty cycles, or by nearly an order of magnitude Δt (from .47E-05 at n=132 to .44E-04 at n=152).

The termination at cycle 197 represents another 10 minutes of running time. For the following run, C5 was increased to 20, but already the shock forming in the first zones of region 2 has raised the shock stability limit (LAMBDA) so that radiation limits as defined by C5 and GAMMA cease to restrict the time steps. GAMMA soon remains equal to ½ (its initial value when searching for the largest value) and Δt is reduced by the LAMBDA criterion as the shock continues to grow.

By the last cycle, (n=259) some 30% of the energy has diffused from region 1 into region 2, and a shock is beginning to grow at the outer edge of the radiation sphere in region 2 as well as from the rapid expansion at the inner edge. Carried to later times, the hydrodynamic expansion would soon dominate, and only slight radiative changes would be seen. Eventually, the grey-body radiation loss routine (CDR) would reduce the energy remaining behind the shock and lower the total net energy, but the radiation diffusion will all but cease, and could be eliminated at late stages without serious error. An appropriate choice of the critical temperature Z1 will keep JSTAR from growing beyond the hot region and will thus restrict the calculation of radiation diffusion to just those inner zones that remain hot after the shock passes.

HAROLD EXAMPLE 2--NO.27--IMP.--S.P. 10/6/66--C5=1.5 IN REG. 1,2

```
 ANALYTIC EQUATION  OF STATE FOR ALUMINUM
  FUNCTION FP1000(T,V)
  FP1000=(36.18*(920.+T**2)*T)/(V*(T**2+1.08E+4))
  RETURN
  END


  FUNCTION FE1000(T,V)
  FE1000=(T*E.27E+1/(T*(1.+.12/V**.25)+116.1/V**.25))*(649.+T**2)/
 1 (100.+T)
  RETURN
  END


  FUNCTION FK1000(T,V)
  FK1000=.225E+5 + (.2E+7*(1.+.237E-16*T**5)*V**(-1))/(1.+.817E-17*
 1 T**6) + (.423E+10*T**2*V**(-.5))/(1.+.02*T**3+.176E-6*T**6)
  RETURN
  END
```

AIR EQUATIONS OF STATE FOR GENERATE AND EXECUTE.

```
        AIDATA

PAIR    CONTRL  A,B+5
      A DEC     .7778E-10,.602E-3,.50972E-3,2.20,.971E+4
      B DEC     4.,8.4.2.0.0.8.0.2
AIR     CONTRL  M;X4+9
      M DEC     1.1.2.4.2.3.3.4.10
      N DEC     6.2.3.8.3.6.6.6.16
     X0 DEC     2.236E+5.4.975E+4.1.272E+6,3.892E+7,8.730E+4,4.89E+9,
        ETC     2.774E+4.1.547E+10,0
     X1 DEC     -1.509E+4,-5.463E+3,-1.246E+5,-2.295E+7,3.190E+3,
        ETC     7.125E+8,-7.849E+3,-1.671E+8,1.619E+11
     X2 DEC     0,0,-3.053E+3,0,0,0,0,-6.617E+7,0
     X3 DEC     5.412E+27,1.609E+7,2.615E+7,3.330E+14,4.976E+5,8.368E+17,
        ETC     3.243E+7,8.49E+9,7.275E+18
     X4 DEC     0,0,1.034E+6,0,-1.883E+3,0,-5.494E+6,4.0E+8,0
        END
```

```
       FUNCTION FP1002(T,V)
      DIMENSION X(5)
      LOGICAL RC
      COMMON /PAIR/A(5),B(5)
      RC = .FALSE.
      ETA = 773.395/V
      ETALOG = ALOG(ETA)
      TAU =  T* EXP( -0.086*ETALOG)
      SIGMA =  TAU /(0.9746 + 0.0254 * EXP (-.21556*ETALOG) )
      IF (TAU.LE.1.0) GO TO 2
      TAU=1.0/TAU
      SIGMA=1.0/SIGMA
      RC = .TRUE.
    2 T2  = TAU**2
      X(2) = T2*TAU
      X(1) = X(2)**2*T2
      X(3) = X(1)
      X(4) = SIGMA**12
      X(5) = X(4)
      AC = 1.0
      DO 1 I = 1,5
       IF(.NOT.RC) AC = AC +  B(I)*(A(I)*X(I))/(1.+(A(I)*X(I)))
        IF(RC) AC = AC + A(I)*B(I) / (X(I) + A(I))
    1 CONTINUE
C SET FUNCTION VALUE
       FP1002= 2.8688*AC*T/V
      RETURN
      END
```

```
       FUNCTION FE1002(T,V)
      COMMON /AIR/M(9),N(9),X0(9),X1(9),X2(9),X3(9),X4(9)
      DIMENSION Y(16)
      LOGICAL RC
      RC = .FALSE.
      P=FP1002(T,V)
      EE  = ALOG(773.395/V)
      EEE = EE**2
       Y(1) =(1.01375E-04/P) * EXP( 1.0553*EE)
      OMY  = 1. - Y(1)
      C= 7.4E-02 - 3.764E-03*EE
      IF  (EE.GT.C.0)  C = C -.C05852*EEE
    2 D= 2.357E-C2 - 4.255E-03*EE - 2.52E-04*EEE
      U =        OMY**2 * (Y(1)-C) * (Y(1)-D)
      W =  100.*Y(1) + 1.0
      YY = Y(1)
      IF  (YY.LE.1.0) GO TO 10
      RC = .TRUE.
      Y(1) = 1./YY
   10 Y(2) = Y(1)*Y(1)
      Y(3) = Y(1)*Y(2)
      Y(4) = Y(2)*Y(2)
      Y(5) = Y(1)*Y(4)
      Y(6) = Y(3)*Y(3)
      Y(8) = Y(4)*Y(4)
      Y(10)= Y(8)*Y(2)
      Y(16)= Y(8)*Y(8)
      TP = 0.0
      DO  3 I =1,9
        IM = M(I)
        IN = N(I)
      IF(I.EQ.6) X1(6)=SIGN(X1(6),EE)
        ENUM = (X0(I) + X1(I) * EE + X2(I) * EEE ) *OMY
        IF (I.EQ.8) ENUM = ENUM * U
        EDEN = (X3(I) + X4(I) * EE)
        IF (I.EQ.3) EDEN = EDEN * W
        IF (RC) GO TO 11
        ENUM = ENUM*Y(IM)
        EDEN = EDEN*Y(IN) + 1.0
        GO TO 12
   11   INM = IN - IM
        ENUM = ENUM * Y(INM)
        EDEN = EDEN + Y(IN)
   12   TP = TP + ENUM/EDEN
    3 CONTINUE
      EMU    = TP + 1. + (27.*YY   + 3.) / (5.*YY   + 1.)
C  FUNCTION NAME HERE
      FE1002= P*V*(EMU-1.0)/2.0
      RETURN
      END
```

```
      FUNCTION FK1002(T,V)
      ETA = 773.395/V
      ETA2 = 1./ETA
      T4 = T**4
      T8 = T4**2
      T6 = T4*T**2
      A1 =ETA2*(.912/(2.5+.51*ETA)+5.3E-5/ETA**2)
      B = 0.01075*ETA2/(1.0+0.025*ETA)   + 1.995E-6/ETA**3
      C = 1.E-6*(ETA2*(.7767+ETA2*(3.933+1.3*ETA2)))
      CFAC = C/T8
      A=A1/(B+CFAC+T8)
      F=.01*ETA**(-1.5)*T6/(1.+T8)
      G = .0003*ETA**(-1.82)*T6/(2.+T6)
      IF (ETA-1.) 2,2,3
    2 EX = -.3
      GO TO 4
    3 EX = .3
    4 H =((1.+1.16E-9*ETA**(EX)*T4)/(1.+1.65E-8 *ETA**(EX)*T4))*(2.2E-8
     1 *ETA**(-1.72)*T4)/(1.+3.82E-11*ETA**(-.72)*T4)
      AMB = A+F+G+H
      FK1002=1.3212*10.**3*V/AMB
      RETURN
      END
```

```
      SUBROUTINE ECHECK
      COMMON /IKA2/ ERS(6,10), ES(6,10), THRS(6,10), TMS(6,10), RS(10),
     1 JS(10), NRS(10), NZS(10), RRG(15), JREG(15), C1(15), C2(15),
     2 C3(15), C4(15), C5(15), EO(15), EMIN(6), EMAX(6), KMIN(6),
     3 KMAX(6), PMIN(6), PMAX(6), TMIN(6), TMAX(6), UMIN(6), UMAX(6),
     4TEMIN(6), TEMAX(6), TKMIN(6), TKMAX(6), TPMIN(6), TPMAX(6), NKMAX,
     5 TTMIN(6), TTMAX(6), TUMIN(6), TUMAX(6), NEMIN, NEMAX, NKMIN,
     6 NPMIN, NPMAX, NTMIN, NTMAX, NUMIN, NUMAX, NRSRCE, NZSRCE,
     7 JC, JOS, JOM, DRC, Z1, Z2, JL, X1, X2, X3, X4, X5, X6, NS,NF,
     8 UNCGS, UNMKS, TM, DT, DTP, JSTAR, JHAT, JMAX, DELTA, REGNO, JZ,
     9NREG,NFOS,RMIN,RMAX,IRAD
      COMMON /IKA2B/ NDH(6), NHC(6), DTH(6), CTH(6), NDP(6), NPC(6),
     1  DTPR(6), CTP(6), NDCK(6), NCKC(6), DTCK(6), CTCK(6),
     2  N, ICK, IH, IP, ICK2, IH2, IP2, TMCKL, TMHL, DTS, DTPS, IC,
     3  IRETRN, TMPL, NPRT, NENCK, NHIST
      COMMON /UC/ U(1)
      COMMON /EGC/ EG(1)
      COMMON /DMASSC/ DMASS(1)
      COMMON /CKCOM/ CKY(15)
      COMMON /SUM2C / SUM2(15)
      COMMON /EGMC /EGM(1)
      INTEGER  DELTA, REGNO, UNCGS, UNMKS
      REAL  KMIN, KMAX, KP, KM, KDM
      DIMENSION CKE(15), CKK(15), CKW(15)
      DO 10 I=1,NREG
      CKE(I)=0.
      CKK(I)=0.
   10 CKW(I)=0.
      IR=1
      J=1
   15 SUM1=0.
      SUM3=0.
   20 SUM1=SUM1+.5*DMASS(J+1)*(EG(J+1)+EGM(J+1))
      SUM3=SUM3+DMASS(J+1)*(U(J)**2+U(J+1)**2)
      J=J+1
      IF(J.LE.JREG(IR)) GO TO 20
      IF(DELTA.EQ.3) CKC=3.003E-3
      IF(DELTA.EQ.2) CKC=1.5015E-3
      IF(DELTA.EQ.1) CKC=2.389E-4
      CKE(IR)=(SUM1-SUM2(IR))*CKC
      CKK(IR)=SUM3*CKC/4.
      CKW(IR)=CKE(IR)+CKK(IR)
   35 IR=IR+1
      IF(IR.LE.NREG) GO TO 15
      IR=1
      PRINT 7000
 7000 FORMAT(1H0,8X,1HE,15X,1HK,15X,1HW,15X,1HY,13X,5HW-Y+Y,13X,4HJREG)
   40 CKYO=CKY(IR-1)
      IF(IR.EQ.1) CKYO=0.
      WTERM=CKW(IR)-CKYO+CKY(IR)
      PRINT 7001,CKE(IR),CKK(IR),CKW(IR),CKY(IR),WTERM,JREG(IR)
 7001 FORMAT(1H 5E16.6,I10,E22.6,E16.6)
      IR=IR+1
      IF(IR.LE.NREG) GO TO 40
      CKES=0.
      CKKS=0.
      CKWS=0.
      DO 50 IR=1,NREG
      CKES=CKES+CKE(IR)
      CKKS=CKKS+CKK(IR)
   50 CKWS=CKWS+CKW(IR)
      PRINT 7001, CKES,CKKS,CKWS
      RETURN
      END
```

All of the preceding information is documentation. Any amount or type of information desired for this purpose is allowable. It goes between the $ENTRY GMAIN card and the START data card. The only restriction is that there must be no $ in column 1. In the case of a subroutine which you would like to include, the $IBFTC (or $IBMAP) card must be removed. If a $ is encountered the program stops and you get the message "END OF DATA ENCOUNTERED ON FTC09."

```
HISTORYS.
EVERY    50 CYCLES UNTIL CYCLE  5000
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0

PRINT OUTS.
EVERY     1 CYCLES UNTIL CYCLE     3
EVERY     7 CYCLES UNTIL CYCLE    10
EVERY    10 CYCLES UNTIL CYCLE  5000
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0

ENERGY CHECKS.
EVERY     1 CYCLES UNTIL CYCLE     3
EVERY     7 CYCLES UNTIL CYCLE    10
EVERY    10 CYCLES UNTIL CYCLE  5000
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0
EVERY     0 CYCLES UNTIL CYCLE     0

RMIN=   0.

SPHERICAL GEOMETRY.

REGION     1. MATERIAL  1000.
C1=  0.6000E 01. C2=  0.5000E 00. C3=  0.1600E 01. C4=  0.2400E 02. C5=  0.1500E 01. FO= -0.1000E 01.
```

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	FL
1	0.9292E-01	0.	0.2932E-01	0.3705E 00	0.2439E 00	0.1057E 00	0.1139E 08	0.1139E 08	0.7217E-03	0.
2	0.1171E 00	0.	0.2932E-01	0.3705E 00	0.2439E 00	0.1057E 00	0.1139E 08	0.1139E 08	0.7214E-03	0.
3	0.1340E 00	0.	0.2932E-01	0.3705E 00	0.2439E 00	0.1057E 00	0.1139E 08	0.1139E 08	0.7217E-03	0.
4	0.1475E 00	0.	0.2932E-01	0.3705E 00	0.2439E 00	0.1057E 00	0.1139E 08	0.1139E 08	0.7217E-03	0.
5	0.1589E 00	0.	0.2932E-01	0.3705E 00	0.2439E 00	0.1057E 00	0.4297E 14	0.1139E 08	0.7217E-03	0.8275E-22

```
REGION     2. MATERIAL  1002.
C1=  0.6000E 01. C2=  0.5000E 00. C3=  0.1600E 01. C4=  0.2400E 02. C5=  0.1500E 01. FO= -0.1000E 01.
```

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	FL
6	0.1218E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7218E-03	0.
7	0.1535E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7219E-03	0.
8	0.1756E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7219E-03	0.
9	0.1933E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7219E-03	0.
10	0.2082E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7219E-03	0.
11	0.2225E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7241E-03	0.
12	0.2363E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8735E-03	0.
13	0.2499E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9608E-03	0.

J	R	U	TEM	VL	PR	FG	KP	KM	DMASS	FL
14	0.2632E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1057E-02	0.
15	0.2765E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1163E-02	0.
16	0.2898E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1279E-02	0.
17	0.3032E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1407E-02	0.
18	0.3166E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1547E-02	0.
19	0.3301E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1702E-02	0.
20	0.3439E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1872E-02	0.
21	0.3578E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2060E-02	0.
22	0.3720E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2266E-02	0.
23	0.3864E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2492E-02	0.
24	0.4012E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2741E-02	0.
25	0.4162E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3016E-02	0.
26	0.4316E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3317E-02	0.
27	0.4473E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3649E-02	0.
28	0.4635E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4014E-02	0.
29	0.4800E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4415E-02	0.
30	0.4970E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4857E-02	0.
31	0.5144E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5342E-02	0.
32	0.5322E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5877E-02	0.
33	0.5506E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6464E-02	0.
34	0.5695E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7111E-02	0.
35	0.5889E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7822E-02	0.
36	0.6089E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8604E-02	0.
37	0.6295E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9464E-02	0.
38	0.6507E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1041E-01	0.
39	0.6725E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1145E-01	0.
40	0.6949E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1260E-01	0.
41	0.7181E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1386E-01	0.
42	0.7419E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1524E-01	0.
43	0.7665E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1677E-01	0.
44	0.7918E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1844E-01	0.
45	0.8179E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2029E-01	0.
46	0.8448E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2237E-01	0.
47	0.8725E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2455E-01	0.
48	0.9011E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2700E-01	0.
49	0.9306E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2970E-01	0.
50	0.9611E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3267E-01	0.
51	0.9925E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3594E-01	0.
52	0.1025E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3954E-01	0.
53	0.1058E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4349E-01	0.
54	0.1093E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4784E-01	0.
55	0.1128E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5262E-01	0.
56	0.1165E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5788E-01	0.
57	0.1203E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6367E-01	0.
58	0.1242E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7004E-01	0.
59	0.1282E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7704E-01	0.
60	0.1324E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8475E-01	0.
61	0.1367E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9322E-01	0.

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	EL
62	0.1411E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1025E 00	0.
63	0.1457E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1128E 00	0.
64	0.1504E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1241E 00	0.
65	0.1553E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1365E 00	0.
66	0.1603E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1501E 00	0.
67	0.1655E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1651E 00	0.
68	0.1708E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1817E 00	0.
69	0.1764E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1998E 00	0.
70	0.1821E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2198E 00	0.
71	0.1879E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2418E 00	0.
72	0.1940E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2660E 00	0.
73	0.2003E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2926E 00	0.
74	0.2068E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3218E 00	0.
75	0.2134E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3540E 00	0.
76	0.2203E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3894E 00	0.
77	0.2275E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4284E 00	0.
78	0.2348E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4712E 00	0.
79	0.2424E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5183E 00	0.
80	0.2502E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5701E 00	0.
81	0.2583E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6272E 00	0.
82	0.2667E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6899E 00	0.
83	0.2753E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7589E 00	0.
84	0.2842E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8347E 00	0.
85	0.2933E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9182E 00	0.
86	0.3028E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1010E 01	0.
87	0.3126E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1111E 01	0.
88	0.3227E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1222E 01	0.
89	0.3321E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1344E 01	0.
90	0.3439E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.	0.	0.1479E 01	0.

SOURCE OR SINK IN ZONE 1
DELTA E= 0.4613200E 10 X 1.E-10 ERGS/MSEC. UNTIL 0.1000000E-03 MSECS.

DT= 0.1031335E-05, DTP= 0.2062670E-05.

MASS ADD INFO.
JO= 4. JLS= 0. JOM= 80. DR= -0.3000000E-01.

PERCENTS.
X1= 0.2000E-05, X2= 0.8000E-05, X3= 0.4000E-05, X4= 0.2000E-05, X5= 0.1000E 00, X6= 0.2000E-03.

Z2= 0.2931000E-01. JHAT= 7. JL= 89. Z1= 0.3000000E-01. JSTAR= 3.

NF= 5000

```
NS= 59999  IRAD=     7  10/6/66-HAR. TEST CASE 2-S.P.-IMP.

      C1           C2           C3           C4           C5
 0.6000E 01   0.5000E 00   0.1600E 01   0.2400E 02   0.1500E 01
 0.6000E 01   0.5000E 00   0.1600E 01   0.2400E 02   0.1500E 01

   J0    JOS    JCM          DRC
    4      0     80 -0.3000E-01

      Z1           Z2          JL     JHAT    JSTAR
 0.3000E-01   0.2931E-01      89        7        3

      X1           X2           X3           X4           X5           X6
 0.2000E-05   0.8000E-05   0.4000E-05   0.2000E-05   0.1000E 00   0.2000E-03
```

RADIUS IS PRINTED IN FEET

PVELOC IS PRINTED IN FT/SEC

PRESUR IS PRINTED IN PSI

DENSTY IS PRINTED IN KG/M3

INTENG IS PRINTED IN CAL/GM

TEMP IS PRINTED IN KELVIN

DYNPRS IS PRINTED IN PSI

ARTVIS IS PRINTED IN PSI

LMNSTY IS PRINTED IN KT/SEC

ROSMFP IS PRINTED IN FEET

NETPWR IS PRINTED IN CAL/SC

RALORT IS PRINTED IN CAL/SC

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MATERIAL	1000											
1	0.	2.526E 01	2.932E 02	3.048E-01	2.699E 03	3.536E 04	0.	0.	0.	1.41E-04	0.	0.
2	0.	2.526E 01	2.932E 02	3.841E-01	2.699E 03	3.536E 04	0.	0.	0.	1.41E-04	0.	0.
3	0.	2.526E 01	2.932E 02	4.396E-01	2.699E 03	3.536E 04	0.	0.	0.	1.41E-04	0.	0.
4	0.	2.526E 01	2.932E 02	4.839E-01	2.699E 03	3.536E 04	0.	0.	0.	1.41E-04	0.	0.
5	0.	2.526E 01	2.932E 02	5.213E-01	2.699E 03	3.536E 04	0.	0.	2.485E-22	1.41E-04	9.37E-13	0.
MATERIAL	1002											
6	0.	5.010E 01	2.930E 02	3.997E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	-5.99E-18	0.
7	0.	5.010E 01	2.930E 02	5.034E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
8	0.	5.010E 01	2.930E 02	5.762E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
9	0.	5.010E 01	2.930E 02	6.342E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
10	0.	5.010E 01	2.930E 02	6.831E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
1	0.206267E-05	0.206267E-05	0.2715E-06	1	0.7654E-04	1	0.5625E 00	1	4	3	7	3

E	K	W	Y	W-Y+Y	JREG
0.103109E-01	0.418975E-16	0.103109E-01	0.304500E-19	0.103109E-01	5
0.	0.419082E-16	0.419082E-16	0.995772E-33	0.416777E-16	90
0.103109E-01	0.838057E-16	0.103109E-01			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL	1000											
1	0.	2.274E 06	2.675E 06	3.048E-01	2.699E 03	3.335E 09	0.	5.95E 01	7.676E 01	1.23E-04	3.09E 10	-1.00E 19
2	0.	3.399E 01	3.946E 02	3.841E-01	2.699E 03	4.760E 04	0.	1.16E 01	9.302E-14	9.89E-05	-9.58E 10	-0.
3	0.	2.526E 01	2.932E 02	4.396E-01	2.699E 03	3.536E 04	0.	8.10E 00	1.404E-25	1.41E-04	-2.36E-04	-0.
4	0.	2.526E 01	2.932E 02	4.839E-01	2.699E 03	3.536E 04	0.	6.44E 00	0.	1.41E-04	-4.47E-16	1.86E-07
5	2.885E-02	2.526E 01	2.932E 02	5.213E-01	2.699E 03	3.536E 04	3.783E-06	5.44E 00	2.485E-22	1.41E-04	9.37E-13	2.95E 01
MATERIAL	1002											
6	0.	5.010E 01	2.930E 02	3.997E 00	1.200E 00	1.463E 01	1.682E-09	2.61E-01	0.	8.38E-08	-5.99E-18	9.65E-13
7	0.	5.010E 01	2.930E 02	5.034E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
8	0.	5.010E 01	2.930E 02	5.762E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
9	0.	5.010E 01	2.930E 02	6.342E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
10	0.	5.010E 01	2.930E 02	6.831E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
2	0.438317E-05	0.232050E-05	0.1220E-02	2	0.1738E-03	1	0.5625E 00	1	4	3	7	3

E	K	W	Y	W-Y+Y	JREG
0.322210E-01	0.394002E-06	0.322214E-01	0.951564E-19	0.322214E-01	5
0.	0.409341E-15	0.409341E-15	0.311179E-32	0.409246E-15	90
0.322210E-01	0.394002E-06	0.322214E-01			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL	1000											
1	1.978E 03	4.831E 06	4.427E 06	3.048E-01	2.699E 03	5.983E 09	1.779E 04	0.	1.619E 03	2.62E-04	1.39E 12	-1.00E 19
2	1.152E-02	2.510E 02	2.927E 03	3.841E-01	2.699E 03	3.531E 05	1.779E 04	3.08E 05	1.345E-11	2.67E-06	-5.47E 10	-0.
3	2.045E-06	2.526E 01	2.932E 02	4.396E-01	2.699E 03	3.536E 04	6.035E-07	0.	2.390E-26	1.41E-04	-3.41E-02	-0.
4	1.502E-06	2.526E 01	2.932E 02	4.839E-01	2.699E 03	3.536E 04	5.720E-14	0.	0.	1.41E-04	-7.61E-17	1.86E-07
5	9.017E-02	2.526E 01	2.932E 02	5.213E-01	2.699E 03	3.536E 04	3.695E-05	0.	2.485E-22	1.41E-04	9.37E-13	2.95E 01
MATERIAL	1002											
6	2.666E-05	5.010E 01	2.930E 02	3.997E 00	1.200E 00	1.463E 01	1.644E-08	0.	0.	8.38E-08	-5.99E-18	9.65E-13
7	0.	5.010E 01	2.930E 02	5.034E 00	1.200E 00	1.463E 01	1.436E-15	0.	0.	8.38E-08	0.	0.
8	0.	5.010E 01	2.930E 02	5.762E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
9	0.	5.010E 01	2.930E 02	6.342E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
10	0.	5.010E 01	2.930E 02	6.831E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

```
 N        TIME            DT          LAMBDA    JLAM    OMEGA      JOMEGA    GAMMA      JGAM   JO  JSTAR  JHAT   IC
 3   0.699374E-05    0.261057E-05   0.4142E-02    2    0.3174E-03     1    0.5625E 00     1     4     3     7     3

        E              K              W              Y              W-Y+Y           JREG
 0.568668E-01   0.358876E-05   0.568704E-01   0.167951E-18   0.568704E-01        5
 0.             0.127508E-14   0.127508E-14   0.549230E-32   0.127491E-14       90
 0.568668E-01   0.358876E-05   0.568704E-01

 J PVELOC     INTENG     TEMP       RADIUS     DENSTY     PRESUR     DYNPRS     ARTVIS     LMNSTY     ROSMFP     NETPWR     RALORT
 0 0.         0.         0.         0.         0.         0.         0.         0.         0.         0.         0.         -0.
MATERIAL  1000
 1 5.971E 02  7.707E 06  6.216E 06  3.049E-01  2.698E 03  8.635E 09  1.620E 05  0.         8.934E 03  4.05E-04  1.19E 13 -1.00E 19
 2 6.743E-01  1.770E 03  2.118E 04  3.841E-01  2.700E 03  2.566E 06  1.621F 05  2.52E 06   7.933E-10  6.13E-08 -6.91F 09 -0.
 3 2.045E-06  2.526E 01  2.932E 02  4.396E-01  2.699E 03  3.536E 04  2.066F-03  0.         1.602E-24  1.41E-04 -2.01E 03 -0.
 4 1.503E-06  2.526E 01  2.932E 02  4.839E-01  2.699E 03  3.536E 04  5.723E-14  0.         0.         1.41E-04 -5.10E-15  1.86E-07
 5 1.591E-01  2.526E 01  2.932E 02  5.213E-01  2.699E 03  3.536E 04  1.151E-04  0.         2.485E-22  1.41E-04  9.37E-13  2.95E 01
MATERIAL  1002
 6 2.666E-05  5.010E 01  2.930E 02  3.997E 00  1.200E 00  1.463E 01  5.119E-08  0.         0.         8.38E-08 -5.99E-18  9.65E-13
 7 0.         5.010E 01  2.930E 02  5.034E 00  1.200E 00  1.463E 01  1.436E-15  0.         0.         8.38E-08  0.         0.
 8 0.         5.010E 01  2.930E 02  5.762E 00  1.200E 00  1.463E 01  0.         0.         0.         8.38E-08  0.         0.
 9 0.         5.010E 01  2.930E 02  6.342E 00  1.200E 00  1.463E 01  0.         0.         0.         8.38E-08  0.         0.
10 0.         5.010E 01  2.930E 02  6.831E 00  1.200E 00  1.463E 01  0.         0.         0.         8.38E-08  0.         0.
 N        TIME            DT          LAMBDA    JLAM    OMEGA      JOMEGA    GAMMA      JGAM   JO  JSTAR  JHAT   IC
 4   0.993063E-05    0.293689E-05   0.9717E-02    2    0.5321E-03     1    0.5625E 00     1     4     3     7     4
 5   0.132346E-04    0.330400E-05   0.1937E-01    2    0.8490E-03     1    0.5625E 00     1     4     3     7     5
 6   0.169516E-04    0.371700E-05   0.3499E-01    2    0.1303E-02     1    0.5625E 00     1     4     3     7     4
 7   0.211332E-04    0.418162E-05   0.5772E-01    2    0.1912E-02     1    0.5625E 00     1     4     3     7     4
 8   0.258376E-04    0.470433E-05   0.8427E-01    2    0.2657E-02     1    0.5625E 00     1     4     3     7     4
 9   0.311299E-04    0.529237E-05   0.1037E 00    2    0.3507E-02     1    0.5625E 00     1     4     3     7     4
10   0.370839E-04    0.595391E-05   0.9868E-01    3    0.6931E-02     2    0.8247E 00     1     4     3     7     6

        E              K              W              Y              W-Y+Y           JREG
 0.339400E 00   0.159692E-02   0.340997E 00   0.100700E-17   0.340997E 00        5
 0.             0.458344E-13   0.458344E-13   0.329308E-31   0.458334E-13       90
 0.339400E 00   0.159692E-02   0.340997E 00

 J PVELOC     INTENG     TEMP       RADIUS     DENSTY     PRESUR     DYNPRS     ARTVIS     LMNSTY     ROSMFP     NETPWR     RALORT
 0 0.         0.         0.         0.         0.         0.         0.         0.         0.         0.         0.         -0.
MATERIAL  1000
 1 1.197E 05  2.665E 07  1.538E 07  3.069E-01  2.645E 03  2.328E 10  6.380E 07  0.         9.559E 06  1.86E-02  5.81E 17 -1.00E 19
 2 3.915E 04  1.386E 07  9.696E 06  3.844E-01  2.740E 03  1.412E 10  1.165F 08  2.32E 08   4.006F 05  2.01E-03 -2.38F 17 -0.
 3 1.253E 02  1.491E 05  6.099E 05  4.396E-01  2.714E 03  2.775E 08  7.064E 06  1.27E 08   5.974E-03  8.35E-07 -6.06F 12 -0.
 4 9.936E-04  2.526E 01  2.932E 02  4.839E-01  2.699E 03  3.537E 04  7.134E 01  4.79E 03   0.         1.41E-04 -1.90E 07  1.86F-07
 5 9.541E-01  2.526E 01  2.932E 02  5.213E-01  2.699E 03  3.536E 04  4.146F-03  0.         2.485E-22  1.41E-04  9.37E-13  2.95F 01
MATERIAL  1002
 6 2.666E-05  5.010E 01  2.930E 02  3.997E 00  1.200E 00  1.463E 01  1.840E-06  0.         0.         8.38E-08 -5.99F-18  9.65E-13
 7 0.         5.010E 01  2.930E 02  5.034E 00  1.200E 00  1.463E 01  1.436E-15  0.         0.         8.38E-08  0.         0.
 8 0.         5.010E 01  2.930E 02  5.762E 00  1.200E 00  1.463E 01  0.         0.         0.         8.38F-08  0.         0.
 9 0.         5.010E 01  2.930E 02  6.342E 00  1.200E 00  1.463E 01  0.         0.         0.         8.38E-08  0.         0.
10 0.         5.010E 01  2.930E 02  6.831E 00  1.200E 00  1.463E 01  0.         0.         0.         8.38F-08  0.         0.
```

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
11	0.437820E-04	0.669815E-05	0.1516E 00	3	0.5733E-02	2	0.9543E 00	1	4	4	7	5
12	0.450744E-04	0.529237E-05	0.1651E 00	3	0.3918E-02	2	0.9267E 00	1	4	4	7	4
13	0.532560E-04	0.418162E-05	0.1547E 00	3	0.3167E-02	2	0.8945E 00	1	4	4	7	4
14	0.569730E-04	0.371700E-05	0.1400E 00	3	0.3279E-02	3	0.9314E 00	1	4	4	7	5
15	0.606900E-04	0.371700E-05	0.1436E 00	4	0.4103E-02	3	0.9579E 00	1	4	4	7	4
16	0.644070E-04	0.371700E-05	0.1958E 00	4	0.4747E-02	3	0.9900E 00	1	4	5	7	4
17	0.681240E-04	0.371700E-05	0.2125E 00	4	0.4050E-02	3	0.9848E 00	2	4	5	7	4
18	0.714280E-04	0.330400E-05	0.2057E 00	4	0.3300E-02	3	0.9780E 00	2	4	5	7	3
19	0.743649E-04	0.293689E-05	0.1820E 00	4	0.2642E-02	3	0.9231E 00	2	4	5	7	4
20	0.769754E-04	0.261057E-05	0.1696E 00	4	0.2658E-02	3	0.9570E 00	2	4	5	7	4

E	K	W	Y	W-Y+Y	JRFG
0.745522E 00	0.110914E-01	0.756613E 00	0.247137E-10	0.756613E 00	5
0.	0.233260E-07	0.233260E-07	0.730608E-31	0.233013E-07	99
0.745522E 00	0.110914E-01	0.756613E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL	1000											
1	1.651E 05	2.894E 07	1.608E 07	3.129E-01	2.495E 03	2.341E 10	1.146E 08	0.	9.475E 06	2.41E-02	7.29E 17	-1.02E 19
2	1.966E 05	2.409E 07	1.439E 07	3.905E-01	2.644E 03	2.142E 10	5.826E 08	0.	8.874E 06	1.44E-02	-1.11E 17	-0.
3	2.003E 05	2.034E 07	1.288E 07	4.429E-01	2.800E 03	1.980E 10	7.425E 08	0.	8.286E 06	7.91E-03	-8.88E 16	-0.
4	6.440E 04	1.017E 07	7.686E 06	4.843E-01	2.858E 03	1.146E 10	3.371E 08	1.45E 09	1.833E 05	6.65E-04	-1.30E 17	3.98E 03
5	6.807E 02	5.232E 04	3.563E 05	5.213E-01	2.729E 03	9.254E 07	1.946E 07	3.85E 08	9.016E-04	2.26E-27	-1.12E 12	1.42E 1?
MATERIAL	1002											
6	4.992E-05	5.010E 01	2.930E 02	3.997E 00	1.200E 00	1.463E 01	9.362E-01	9.39E-01	0.	8.38E-08	-2.17E 01	9.65E-13
7	0.	5.010E 01	2.930E 02	5.034E 00	1.200E 00	1.463E 01	5.035E-15	0.	0.	8.38E-08	0.	0.
8	0.	5.010E 01	2.930E 02	5.762E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
9	0.	5.010E 01	2.930E 02	6.342E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
10	0.	5.010E 01	2.930E 02	6.831E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
21	0.795860E-04	0.261057E-05	0.1486E 00	4	0.2701E-02	4	0.9837E 00	2	4	5	7	4
22	0.821966E-04	0.261057E-05	0.1517E 00	5	0.2464E-02	4	0.8990E 00	2	4	5	7	4
23	0.845171E-04	0.232050E-05	0.1815E 00	5	0.2703E-02	4	0.9274E 00	2	4	6	7	4
24	0.868376E-04	0.232050E-05	0.2055E 00	5	0.2875E-02	4	0.9635E 00	2	4	6	7	4
25	0.891581E-04	0.232050E-05	0.1981E 00	5	0.2359E-02	4	0.8920E 00	2	4	6	7	5
26	0.912207E-04	0.206267E-05	0.2053E 00	5	0.2408E-02	4	0.9228E 00	2	4	6	7	7
27	0.932834E-04	0.206267E-05	0.2056E 00	5	0.2439E-02	4	0.9505E 00	2	4	6	7	5
28	0.953461E-04	0.206267E-05	0.1992E 00	5	0.2459E-02	4	0.9741E 00	2	4	6	7	5
29	0.974088E-04	0.206267E-05	0.1860E 00	5	0.2472E-02	4	0.9943E 00	2	4	6	7	4
30	0.994714E-04	0.206267E-05	0.1476E 00	5	0.1960E-02	4	0.8991E 00	2	4	6	7	4

E	K	W	Y	W-Y+Y	JRFG
0.962403E 00	0.197552E-01	0.982158E 00	0.129679E-02	0.983455E 00	5
0.153666E-02	0.574472E-03	0.211113E-02	0.126094E-09	0.814342E-03	99
0.963940E 00	0.203297E-01	0.984269E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.767E 05	2.945E 07	1.618E 07	3.168E-01	2.404E 03	2.283E 10	1.264E 08	0.	9.588E 06	2.61E-02	7.30E 17	-1.03E 19
2	2.093E 05	2.506E 07	1.471E 07	3.951E-01	2.558E 03	2.136E 10	6.417E 08	0.	9.135E 06	1.67E-02	-9.54E 16	-0.
3	2.367E 05	2.212E 07	1.361E 07	4.480E-01	2.709E 03	2.049E 10	9.076E 08	0.	8.616E 06	1.08E-02	-1.06E 17	-0.
4	2.439E 05	1.911E 07	1.235E 07	4.883E-01	2.887E 03	1.943E 10	1.123E 09	0.	8.065E 06	6.11E-03	-8.36E 16	-0.
5	1.068E 05	1.138E 07	8.393E 06	5.221E-01	2.950E 03	1.299E 10	6.109E 08	1.53E 09	8.364E 05	9.90E-04	-1.90E 17	-0.
MATERIAL 1002												
6	2.462E 00	2.381E 05	1.023E 05	3.997E 00	1.200E 00	3.747E 04	2.306E 04	1.65E 03	5.772E-02	2.38E-03	-5.72E 14	7.14E 19
7	8.299E-07	5.012E 01	2.931E 02	5.034E 00	1.200E 00	1.463E 01	1.225E-05	0.	0.	8.40E-08	-4.58E 03	0.
8	0.	5.010E 01	2.930E 02	5.762E 00	1.200E 00	1.463E 01	1.392E-18	0.	0.	8.38E-08	0.	0.
9	0.	5.010E 01	2.930E 02	6.342E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
10	0.	5.010E 01	2.930E 02	6.831E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
31	0.101305E-03	0.183348E-05	0.1412E 00	5	0.2484E-02	4	0.9910E 00	2	4	6	8	4
32	0.103368E-03	0.206267E-05	0.1119E 00	5	0.2706E-02	5	0.9227E 00	2	4	7	8	4
33	0.105430E-03	0.206267E-05	0.8586E-01	5	0.3630E-02	5	0.9833E 00	3	4	8	9	14
34	0.107751E-03	0.232050E-05	0.3984E-01	5	0.3751E-02	5	0.9275E 00	3	4	8	9	4
35	0.110071E-03	0.232050E-05	0.1879E-03	6	0.4793E-02	5	0.9802E 00	3	4	8	9	5
36	0.112682E-03	0.261057E-05	0.2112E-03	6	0.4769E-02	5	0.9112E 00	3	4	8	9	5
37	0.115292E-03	0.261057E-05	0.2650E-03	6	0.5945E-02	5	0.9687E 00	6	4	8	9	6
38	0.118229E-03	0.293689E-05	0.2325E-03	6	0.3618E-02	5	0.9116E 00	6	4	8	10	4
39	0.120550E-03	0.232050E-05	0.2262E-03	6	0.2787E-02	5	0.9286E 00	6	4	8	10	4
40	0.122612E-03	0.206267E-05	0.2170E-03	6	0.2146E-02	5	0.9037E 00	6	4	9	10	5

E	K	W	Y	W-Y+Y	JREG
0.860700E 00	0.301256E-01	0.890826E 00	0.954188E-01	0.986245E 00	5
0.952748E-01	0.845625E-02	0.103731E 00	0.138531E-07	0.831233E-02	90
0.955975E 00	0.385819E-01	0.994557E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.774E 05	2.207E 07	1.337E 07	3.209E-01	2.313E 03	1.729E 10	1.225E 08	0.	1.084E 06	1.33E-02	4.49E 16	-0.
2	2.118E 05	2.069E 07	1.287E 07	4.000E-01	2.470E 03	1.758E 10	6.299E 08	0.	2.037E 06	9.94E-03	1.22E 17	-0.
3	2.433E 05	1.930E 07	1.232E 07	4.536E-01	2.609E 03	1.759E 10	9.102E 08	0.	2.863E 06	7.30E-03	1.12E 17	-0.
4	2.824E 05	1.757E 07	1.158E 07	4.945E-01	2.771E 03	1.736E 10	1.290E 09	0.	3.553E 06	4.79E-03	8.13E 16	-0.
5	4.058E 05	1.468E 07	1.016E 07	5.283E-01	2.877E 03	1.557E 10	2.321E 09	0.	3.923E 06	2.31E-03	2.52E 16	-0.
MATERIAL 1002												
6	6.122E 02	5.581E 06	1.443E 06	3.997E 00	1.200E 00	1.321E 06	3.404E 05	2.06E 04	3.842E 06	6.36E 00	-1.48E 17	-0.
7	3.602E 02	4.307E 06	1.110E 06	5.034E 00	1.200E 00	8.868E 05	1.942E 00	3.32E-01	2.835E 06	4.10E 00	-3.39E 13	6.02E 14
8	2.814E 01	1.075E 06	4.630E 05	5.762E 00	1.200E 00	2.853E 05	3.174E-01	7.58E 00	9.225E 03	3.53E-01	-1.37E 18	1.59E 17
9	1.556E-04	1.100E 03	3.919E 03	6.342E 00	1.200E 00	2.004E 02	1.600E-03	3.73E-01	6.636E-03	4.42E 01	-7.04E 17	1.48E-12
10	-3.740E-10	5.010E 01	2.930E 02	6.831E 00	1.200E 00	1.463E 01	5.146E-14	0.	0.	8.38E-08	-1.14E 03	0.
11	0.	5.010E 01	2.930E 02	7.299E 00	1.200E 00	1.463E 01	2.827E-25	0.	0.	8.38E-08	0.	0.
12	0.	5.010E 01	2.930E 02	7.753E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
13	0.	5.010E 01	2.930E 02	8.197E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
41	0.124446E-03	0.183348E-05	0.2305E-03	6	0.2093E-02	5	0.9453E 00	6	4	9	10	5
42	0.126279E-03	0.183348E-05	0.2435E-03	6	0.2037E-02	5	0.9628E 00	6	4	9	10	5
43	0.128113E-03	0.183348E-05	0.2556E-03	6	0.1978E-02	5	0.9669E 00	6	4	9	11	4
44	0.129946E-03	0.183348E-05	0.2690E-03	6	0.1918E-02	5	0.9639E 00	6	4	9	11	4
45	0.131780E-03	0.183348E-05	0.2815E-03	6	0.1857E-02	5	0.9577E 00	6	4	10	11	4
46	0.133613E-03	0.183348E-05	0.2936E-03	6	0.1795E-02	5	0.9487E 00	6	4	10	11	11
47	0.135447E-03	0.183348E-05	0.3072E-03	6	0.1733E-02	5	0.9371E 00	6	4	10	12	5
48	0.137280E-03	0.183348E-05	0.3147E-03	6	0.1671E-02	5	0.9236E 00	6	4	10	12	4
49	0.139114E-03	0.183348E-05	0.3314E-03	6	0.1609E-02	5	0.9084E 00	6	4	10	12	3
50	0.140947E-03	0.183348E-05	0.3433E-03	6	0.1558E-02	4	0.9119E 00	7	4	10	12	3

F	K	W	Y	W-Y+Y	JREG
0.779882E 00	0.432566E-01	0.823138E 00	0.151883E 00	0.975022E 00	5
0.151833E 00	0.195919E-01	0.171424E 00	0.507676E-07	0.195413E-01	90
0.931714E 00	0.628485E-01	0.994563E 00			

HISTORY EDIT AT CYCLE 50.

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	KALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.756E 05	2.007E 07	1.248E 07	3.242E-01	2.245E 03	1.549E 10	1.166E 08	0.	6.257E 05	1.03E-02	1.98E 16	-0.
2	2.118E 05	1.867E 07	1.203E 07	4.039E-01	2.402E 03	1.582E 10	6.071E 08	0.	1.219E 06	7.59E-03	5.54E 16	-0.
3	2.469E 05	1.761E 07	1.150E 07	4.581E-01	2.530E 03	1.579E 10	8.963E 08	0.	1.771E 06	5.52E-03	5.62E 15	-0.
4	3.138E 05	1.597E 07	1.075E 07	4.999E-01	2.651E 03	1.531E 10	1.403E 09	0.	2.239E 06	3.59E-03	4.07E 16	-0.
5	6.238E 05	1.310E 07	9.222E 06	5.381E-01	2.479E 03	1.212E 10	3.670E 09	0.	2.232E 06	1.92E-03	-3.58E 14	-0.
MATERIAL 1002												
6	9.267E 02	5.395E 06	1.393E 06	3.997E 00	1.200E 00	1.255E 06	7.886E 05	5.08E 04	2.366E 06	5.99E 00	2.32E 17	-0.
7	8.533E 02	4.655E 06	1.193E 06	5.034E 00	1.200E 00	9.953E 05	6.402E 00	0.	2.385E 06	4.63E 00	8.45E 16	-0.
8	7.492E 02	3.909E 06	1.031E 06	5.762E 00	1.200E 00	7.840E 05	5.189E 00	0.	2.160E 06	3.60E 00	-1.11E 18	-0.
9	4.361E 02	2.559E 06	8.356E 05	6.342E 00	1.200E 00	5.612E 05	2.839E 00	4.68E 00	1.142E 06	2.32E 00	-4.07E 18	8.29E 04
10	1.433E 01	4.497E 05	1.494E 05	6.831E 00	1.200E 00	7.195E 04	4.099E-01	1.27E 01	3.500E 00	5.38E-03	-1.26E 15	1.32E 12
11	2.262E-04	5.057E 01	2.958E 02	7.299E 00	1.200E 00	1.476E 01	4.151E-04	0.	0.	9.04E-08	-6.76E 05	1.31E-12
12	-2.365E-09	5.010E 01	2.930E 02	7.753E 00	1.200E 00	1.463E 01	1.034E-13	0.	0.	8.38E-08	0.	0.
13	0.	5.010E 01	2.930E 02	8.197E 00	1.200E 00	1.463E 01	1.130E-23	0.	0.	8.38E-08	0.	0.
14	0.	5.010E 01	2.930E 02	8.636E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
15	0.	5.010E 01	2.930E 02	9.073E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
51	0.142781E-03	0.183348E-05	0.3554E-03	6	0.1537E-02	4	0.9239E 00	7	4	11	12	4
52	0.144614E-03	0.183348E-05	0.3675E-03	6	0.1516E-02	4	0.9293E 00	7	4	11	12	5
53	0.146448E-03	0.183348E-05	0.3789E-03	6	0.1495E-02	4	0.9290E 00	7	4	11	12	7
54	0.148281E-03	0.183348E-05	0.3906E-03	6	0.1474E-02	4	0.9247E 00	7	4	11	12	4
55	0.150115E-03	0.183348E-05	0.4022E-03	6	0.1453E-02	4	0.9174E 00	7	4	11	13	4
56	0.151948E-03	0.183348E-05	0.4137E-03	6	0.1432E-02	4	0.9095E 00	7	4	11	13	3
57	0.153782E-03	0.183348E-05	0.4246E-03	6	0.1410E-02	4	0.9009E 00	7	4	11	13	3
58	0.155615E-03	0.183348E-05	0.4365E-03	6	0.1389E-02	4	0.8916E 00	7	4	12	13	3
59	0.157449E-03	0.183348E-05	0.5027E-03	6	0.1730E-02	4	0.9917E 00	7	4	12	13	4
60	0.159511E-03	0.206267E-05	0.5163E-03	6	0.1699E-02	4	0.9779E 00	7	4	12	13	6

E	K	W	Y	W-Y+Y	JREG
0.718274E 00	0.591602E-01	0.777434E 00	0.185566E 00	0.963000E 00	5
0.185538E 00	0.315925E-01	0.217131E 00	0.943864E-07	0.315648E-01	90
0.503812E 00	0.907527E-01	0.994565E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.738E 05	1.868E 07	1.184E 07	3.274E-01	2.179E 03	1.415E 10	1.108E 08	0.	4.313E 05	8.41E-03	1.11E 16	-0.
2	2.125E 05	1.755E 07	1.139E 07	4.078E-01	2.335E 03	1.446E 10	5.866E 08	0.	8.560E 05	6.12E-03	3.23E 16	-0.
3	2.547E 05	1.631E 07	1.085E 07	4.627E-01	2.447E 03	1.432E 10	8.997E 08	0.	1.262E 06	4.38E-03	3.24E 16	-0.
4	3.656E 05	1.463E 07	1.002E 07	5.063E-01	2.492E 03	1.334E 10	1.615E 09	0.	1.549E 06	2.85E-03	1.88E 16	-0.
5	7.921E 05	1.168E 07	8.337E 06	5.515E-01	2.015E 03	8.866E 09	4.548E 09	0.	1.429E 06	1.82E-03	-4.94E 15	-0.
MATERIAL 1002												
6	1.184E 03	5.137E 06	1.322E 06	3.997E 00	1.200E 00	1.163E 06	1.272E 06	8.95E 04	1.543E 06	5.48E 00	1.81E 17	-0.
7	1.094E 03	4.543E 06	1.165E 06	5.034E 00	1.200E 00	9.587E 05	1.049E 01	0.	1.610E 06	4.45E 00	2.87E 17	-0.
8	1.063E 03	4.030E 06	1.053E 06	5.762E 00	1.200E 00	8.126E 05	9.403E 00	0.	1.619E 06	3.74E 00	4.83E 16	-0.
9	9.767E 02	3.365E 06	9.456E 05	6.342E 00	1.200E 00	6.785E 05	8.407E 00	0.	1.504E 06	3.05E 00	-6.05E 17	-0.
10	8.263E 02	2.442E 06	8.189E 05	6.831E 00	1.200E 00	5.454E 05	6.569E 00	5.20E-01	1.245E 06	2.21E 00	-1.17E 18	9.91E 04
11	9.457E 01	1.001E 06	4.213E 05	7.299E 00	1.200E 00	2.582E 05	1.713E 00	3.36E 01	9.790E 03	2.47E-01	-6.53E 17	4.76E 12
12	2.440E-03	1.030E 03	3.786E 03	7.753E 00	1.200E 00	1.922E 02	1.807E-02	6.48E-01	8.066E-03	3.82E 01	-8.24E 17	2.09E-09
13	2.197E-04	5.010E 01	2.930E 02	8.197E 00	1.200E 00	1.463E 01	1.429E-11	0.	0.	8.38E-08	-1.52E 03	0.
14	0.	5.010E 01	2.930E 02	8.636E 00	1.200E 00	1.463E 01	9.755E-14	0.	0.	8.38E-08	0.	0.
15	0.	5.010E 01	2.930E 02	9.073E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
16	0.	5.010E 01	2.930E 02	9.509E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
61	0.161574E-03	0.206267E-05	0.5302E-03	6	0.1668E-02	4	0.9624E 00	7	4	12	13	6
62	0.163637E-03	0.206267E-05	0.5434E-03	6	0.1637E-02	4	0.9455E 00	7	4	12	14	4
63	0.165699E-03	0.206267E-05	0.5575E-03	6	0.1606E-02	4	0.9281E 00	7	4	12	14	4
64	0.167762E-03	0.206267E-05	0.5713E-03	6	0.1575E-02	4	0.9106E 00	7	4	12	14	3
65	0.169825E-03	0.206267E-05	0.5845E-03	6	0.1544E-02	4	0.8933E 00	7	4	12	14	3
66	0.171887E-03	0.206267E-05	0.6720E-03	6	0.1914E-02	4	0.9856E 00	7	4	12	14	3
67	0.174208E-03	0.232050E-05	0.6879E-03	6	0.1870E-02	4	0.9651E 00	7	4	13	14	3
68	0.176528E-03	0.232050E-05	0.7044E-03	6	0.1826E-02	4	0.9450E 00	7	4	13	14	4
69	0.178849E-03	0.232050E-05	0.7216E-03	6	0.1782E-02	4	0.9253E 00	7	4	13	14	6
70	0.181169E-03	0.232050E-05	0.7370E-03	6	0.1738E-02	4	0.9058E 00	7	4	13	14	7

E	K	W	Y	W-Y+Y	JREG
0.659436E 00	0.793857E-01	0.738822E 00	0.211306E 00	0.950128E 00	5
0.211294E 00	0.444474E-01	0.255742E 00	0.169325E-06	0.444356E-01	90
0.870731E 00	0.123833E 00	0.994564E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.718E 05	1.745E 07	1.124E 07	3.311E-01	2.106E 03	1.290E 10	1.047E 08	0.	3.129E 05	6.97E-03	6.59E 15	-0.
2	2.149E 05	1.634E 07	1.079E 07	4.125E-01	2.258E 03	1.316E 10	5.685E 08	0.	6.298E 05	4.97E-03	1.94E 15	-0.
3	2.723E 05	1.508E 07	1.020E 07	4.684E-01	2.344E 03	1.282E 10	9.371E 08	0.	9.278E 05	3.50E-03	1.86E 16	-0.
4	4.442E 05	1.331E 07	9.266E 06	5.151E-01	2.256E 03	1.111E 10	1.951E 09	0.	1.062E 06	2.36E-03	6.90E 15	-0.
5	9.396E 05	1.021E 07	7.410E 06	5.705E-01	1.561E 03	6.072E 09	5.035E 09	0.	9.677E 05	1.91E-03	-3.26E 15	-0.
MATERIAL 1002												
6	1.485E 03	4.898E 06	1.257E 06	3.997E 00	1.201E 00	1.079E 06	1.791E 06	1.41E 05	1.054E 06	5.04E 00	1.27E 17	-0.
7	1.301E 03	4.378E 06	1.126E 06	5.034E 00	1.200E 00	9.074E 05	1.569E 01	0.	1.129E 06	4.20E 00	2.57E 17	-0.
8	1.303E 03	3.948E 06	1.038E 06	5.762E 00	1.200E 00	7.931E 05	1.371E 01	0.	1.164E 06	3.65E 00	2.21E 17	-0.
9	1.257E 03	3.467E 06	9.603E 05	6.342E 00	1.200E 00	6.959E 05	1.324E 01	0.	1.168E 06	3.15E 00	2.19E 16	-0.
10	1.225E 03	2.884E 06	8.800E 05	6.831E 00	1.200E 00	6.056E 05	1.245E 01	0.	1.110E 06	2.61E 00	-3.12E 17	-0.
11	1.140E 03	2.176E 06	7.779E 05	7.299E 00	1.200E 00	5.091E 05	1.130E 01	0.	9.663E 05	1.94E 00	-5.93E 17	1.09E 05
12	2.186E 02	1.189E 06	5.197E 05	7.753E 00	1.200E 00	3.223E 05	3.728E 00	4.60E 01	5.865E 04	5.39E-01	-1.08E 18	8.53E 12
13	7.092E-02	7.777E 03	9.829E 03	8.197E 00	1.200E 00	8.498E 02	9.661E-02	4.59E 00	1.422E-01	1.25E 00	-1.65E 17	1.45E 06
14	2.350E-04	5.012E 01	2.931E 02	8.636E 00	1.200E 00	1.463E 01	1.023E-08	0.	0.	8.40E-08	-2.72E 04	0.
15	0.	5.010E 01	2.930E 02	9.073E 00	1.200E 00	1.463E 01	1.116E-13	0.	0.	8.38E-08	0.	0.
16	0.	5.010E 01	2.930E 02	9.509E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
17	0.	5.010E 01	2.930E 02	9.946E 00	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
71	0.183490E-03	0.232050E-05	0.8472E-03	6	0.2145E-02	4	0.9775E 00	7	4	13	15	4
72	0.186100E-03	0.261056E-05	0.8666E-03	6	0.2084E-02	4	0.9735E 00	7	4	13	15	3
73	0.188711E-03	0.261056E-05	0.8873E-03	6	0.2024E-02	4	0.9503E 00	7	4	13	15	4
74	0.191321E-03	0.261056E-05	0.9069E-03	6	0.1964E-02	4	0.9275E 00	7	4	13	15	3
75	0.193932E-03	0.261056E-05	0.9273E-03	6	0.1905E-02	4	0.9057E 00	7	4	13	15	3
76	0.196543E-03	0.261056E-05	0.1066E-02	6	0.2338E-02	4	0.9959E 00	7	4	14	15	3
77	0.199480E-03	0.293689E-05	0.1090E-02	6	0.2258E-02	4	0.9709E 00	7	4	14	15	3
78	0.202416E-03	0.293689E-05	0.1115E-02	6	0.2179E-02	4	0.9538E 00	8	4	14	15	4
79	0.205353E-03	0.293689E-05	0.1140E-02	6	0.2103E-02	4	0.9400E 00	8	4	14	16	6
80	0.208290E-03	0.293689E-05	0.1165E-02	6	0.2028E-02	4	0.9261E 00	8	4	14	16	5

E	K	W	Y	W-Y+Y	JREG
0.597588E 00	0.105552E 00	0.703540E 00	0.233271E 00	0.936810E 00	5
0.233268E 00	0.577560E-01	0.291023E 00	0.271875E-06	0.577532E-01	90
0.831255E 00	0.163308E 00	0.994563E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	KALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.700E 05	1.624E 07	1.064E 07	3.358E-01	2.020E 03	1.164E 10	9.827E 07	0.	2.316E 05	5.74E-03	3.96E 15	-0.
2	2.215E 05	1.511E 07	1.015E 07	4.184E-01	2.161E 03	1.178E 10	5.576E 08	0.	4.694E 05	4.00E-03	1.15E 16	-0.
3	3.091E 05	1.377E 07	9.486E 06	4.743E-01	2.195E 03	1.110E 10	1.040E 09	0.	6.697E 05	2.79E-03	9.52E 15	-0.
4	5.491E 05	1.185E 07	8.401E 06	5.287E-01	1.925E 03	8.548E 09	2.387E 09	0.	7.029E 05	2.06E-03	1.31E 15	-0.
5	1.071E 06	8.615E 06	6.404E 06	5.980E-01	1.158E 03	3.859E 09	5.116E 09	0.	6.727E 05	2.25E-03	-9.83E 14	-0.
MATERIAL 1002												
6	1.902E 03	4.675E 06	1.198E 06	3.997E 00	1.201E 00	1.003E 06	2.329E 06	2.15E 05	7.385E 05	4.66E 00	9.01E 16	-0.
7	1.507E 03	4.193E 06	1.086E 06	5.035E 00	1.200E 00	8.548E 05	2.348E 01	0.	7.951E 05	3.95E 00	2.16E 17	-0.
8	1.527E 03	3.808E 06	1.014E 06	5.762E 00	1.200E 00	7.618E 05	1.859E 01	0.	8.415E 05	3.49E 00	2.23E 17	-0.
9	1.503E 03	3.413E 06	9.525E 05	6.342E 00	1.200E 00	6.867E 05	1.854E 01	0.	8.696E 05	3.09E 00	1.50E 17	-0.
10	1.502E 03	2.985E 06	8.935E 05	6.831E 00	1.200E 00	6.199E 05	1.825E 01	0.	8.703E 05	2.70E 00	3.48E 15	-0.
11	1.509E 03	2.500E 06	8.272E 05	7.299E 00	1.200E 00	5.532E 05	1.833E 01	0.	8.335E 05	2.26E 00	-1.79E 17	-0.
12	1.479E 03	1.949E 06	7.382E 05	7.753E 00	1.200E 00	4.765E 05	1.805E 01	0.	7.350E 05	1.68E 00	-3.65E 17	-0.
13	3.385E 02	1.218E 06	5.328E 05	8.197E 00	1.200E 00	3.309E 05	6.682E 00	6.54E 01	8.081E 04	5.89E-01	-6.57E 17	9.[illegible]E 12
14	2.180E-01	1.420E 04	1.745E 04	8.636E 00	1.200E 00	1.842E 03	2.324E-01	9.10E 00	2.258E-02	2.56E-02	-4.72E 15	4.03E [illegible]
15	4.370E-06	5.018E 01	2.934E 02	9.073E 00	1.200E 00	1.465E 01	9.603E-08	0.	0.	8.48E-08	-4.39E 03	1.84E-12
16	0	5.010E 01	2.930E 02	9.509E 00	1.200E 00	1.463E 01	3.858E-17	0.	0.	8.38E-08	0.	0.
17	0.	5.010E 01	2.930E 02	9.946E 00	1.200E 00	1.463E 01	0.	1.82E-02	0.	8.38E-08	0.	0.
18	0.	5.010E 01	2.930E 02	1.039E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
19	0.	5.010E 01	2.930E 02	1.083E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	IO	JSTAR	JHAT	IC
81	0.211227E-03	0.293689E-05	0.1190E-02	6	0.1955E-02	4	0.9121E 00	9	4	14	16	4
82	0.214164E-03	0.293689E-05	0.1214E-02	6	0.1911E-02	3	0.8979E 00	8	4	14	16	4
83	0.217101E-03	0.293689E-05	0.1395E-02	6	0.2377E-02	3	0.9944E 00	8	4	14	16	3
84	0.220405E-03	0.330400E-05	0.1425E-02	6	0.2330E-02	3	0.9774E 00	8	4	14	16	3
85	0.223709E-03	0.330400E-05	0.1456E-02	6	0.2283E-02	3	0.9612E 00	8	4	14	16	3
86	0.227013E-03	0.330400E-05	0.1488E-02	6	0.2236E-02	3	0.9504E 00	9	4	15	16	3
87	0.230317E-03	0.330400E-05	0.1519E-02	6	0.2189E-02	3	0.9440E 00	9	4	15	16	3
88	0.233621E-03	0.330400E-05	0.1551E-02	6	0.2142E-02	3	0.9377E 00	9	4	15	16	5
89	0.236925E-03	0.330400E-05	0.1582E-02	6	0.2095E-02	3	0.9307E 00	9	4	15	16	5
90	0.240229E-03	0.330400E-05	0.1614E-02	6	0.2049E-02	3	0.9235E 00	9	4	16	17	2

E	K	W	Y	W-Y+Y	JREG
0.536458E 00	0.136520E 00	0.673017E 00	0.251530E 00	0.924547E 00	5
0.251539E 00	0.700019E-01	0.321541E 00	0.381430E-06	0.700114E-01	90
0.788037E 00	0.206522E 00	0.994558E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALOHT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.693E 05	1.509E 07	1.004E 07	3.412E-01	1.925E 03	1.042E 10	9.294E 07	0.	1.775E 05	4.73E-03	2.46E 15	-0.
2	2.365E 05	1.390E 07	9.500E 06	4.257E-01	2.043E 03	1.037E 10	5.664E 08	0.	3.563E 05	3.22E-03	6.92E 15	-0.
3	3.697E 05	1.242E 07	8.720E 06	4.872E-01	1.985E 03	9.174E 09	1.228E 09	0.	4.730E 05	2.28E-03	4.33E 15	-0.
4	6.631E 05	1.034E 07	7.478E 06	5.483E-01	1.555E 03	6.108E 09	2.793E 09	0.	4.733E 05	1.98E-03	8.76E 12	-0.
5	1.179E 06	7.077E 06	5.437E 06	6.342E-01	8.471E 02	2.370E 09	4.841E 09	0.	4.730E 05	3.05E-03	-8.23E 12	-0.
MATERIAL 1002												
6	2.490E 03	4.464E 06	1.146E 06	3.997E 00	1.202E 00	9.353E 05	2.826E 06	3.16E 05	5.293E 05	4.32E 00	7.23E 16	-0.
7	1.707E 03	4.005E 06	1.049E 06	5.035E 00	1.200E 00	8.064E 05	3.560E 01	0.	5.801E 05	3.71E 00	1.82E 17	-0.
8	1.736E 03	3.647E 06	9.875E 05	5.762E 00	1.200E 00	7.291E 05	2.395E 01	0.	6.239E 05	3.32E 00	2.00E 17	-0.
9	1.725E 03	3.305E 06	9.371E 05	6.342E 00	1.200E 00	6.687E 05	2.419E 01	0.	6.561E 05	2.99E 00	1.56E 17	-0.
10	1.743E 03	2.960E 06	8.901E 05	6.831E 00	1.200E 00	6.164E 05	2.430E 01	0.	6.722E 05	2.69E 00	8.83E 16	-0.
11	1.780E 03	2.593E 06	8.403E 05	7.299E 00	1.200E 00	5.657E 05	2.508E 01	0.	6.693E 05	2.35E 00	-1.44E 16	-0.
12	1.847E 03	2.194E 06	7.809E 05	7.753E 00	1.200E 00	5.117E 05	2.658E 01	0.	6.448E 05	1.96E 00	-1.06E 17	-0.
13	1.824E 03	1.757E 06	6.990E 05	8.197E 00	1.200E 00	4.462E 05	2.722E 01	0.	5.920E 05	1.44E 00	-1.71E 17	1.24E 05
14	3.540E 02	1.080E 06	4.657E 05	8.636E 00	1.200E 00	2.871E 05	9.582E 00	1.09E 02	3.168E 04	3.61E-01	-4.60E 17	9.79E 12
15	1.051E-01	5.376E 03	8.836E 03	9.073E 00	1.200E 00	6.541E 02	2.533E-01	8.70E 00	2.525E-01	2.84E 00	-2.07E 17	7.56E 05
16	2.032E-04	5.013E 01	2.932E 02	9.509E 00	1.200E 00	1.463E 01	2.241E-08	0.	6.275E-18	8.42E-08	-4.98E 04	0.
17	0.	5.010E 01	2.930E 02	9.946E 00	1.200E 00	1.463E 01	8.340E-14	0.	0.	8.38E-08	-1.20E-12	0.
18	0.	5.010E 01	2.930E 02	1.039E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
19	0.	5.010E 01	2.930E 02	1.083E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
20	0.	5.010E 01	2.930E 02	1.128E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
91	0.243533E-03	0.330400E-05	0.1646E-02	6	0.2002E-02	3	0.9158E 00	9	4	16	17	5
92	0.246837E-03	0.330400E-05	0.1678E-02	6	0.1956E-02	3	0.9079E 00	9	4	16	17	4
93	0.250141E-03	0.330400E-05	0.1710E-02	6	0.1911E-02	3	0.8996E 00	9	4	16	17	3
94	0.253445E-03	0.330400E-05	0.1741E-02	6	0.1865E-02	3	0.8917E 00	9	4	16	17	3
95	0.256749E-03	0.330400E-05	0.1996E-02	6	0.2304E-02	3	0.9941E 00	9	4	16	17	3
96	0.260466E-03	0.371699E-05	0.2034E-02	6	0.2241E-02	3	0.9845E 00	9	4	16	17	3
97	0.264183E-03	0.371699E-05	0.2075E-02	6	0.2179E-02	3	0.9750E 00	9	4	16	17	3
98	0.267900E-03	0.371699E-05	0.2115E-02	6	0.2118E-02	3	0.9658E 00	9	4	16	17	3
99	0.271617E-03	0.371699E-05	0.2158E-02	6	0.2058E-02	3	0.9567E 00	9	4	16	17	3
100	0.275334E-03	0.371699E-05	0.2199E-02	6	0.1999E-02	3	0.9478E 00	9	4	16	17	4

E	K	W	Y	W-Y+Y	JREG
0.479368E 00	0.169347E 00	0.648715E 00	0.265614E 00	0.914329E 00	5
0.265637E 00	0.802009E-01	0.345838E 00	0.494027E-06	0.802245E-01	90
0.745005E 00	0.249548E 00	0.994553E 00			

HISTORY EDIT AT CYCLE 100.

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALOHT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.714E 05	1.403E 07	9.481E 06	3.472E-01	1.827E 03	9.285E 09	9.040E 07	0.	1.421E 05	3.96E-03	1.52E 15	-0.
2	2.635E 05	1.273E 07	8.853E 06	4.345E-01	1.902E 03	8.950E 09	6.060E 08	0.	2.742E 05	2.66E-03	4.02E 15	-0.
3	4.463E 05	1.109E 07	7.933E 06	5.017E-01	1.728E 03	7.226E 09	1.466E 09	0.	3.347E 05	2.01E-03	1.81E 15	-0.
4	7.667E 05	8.886E 06	6.576E 06	5.736E-01	1.223E 03	4.194E 09	3.030E 09	0.	3.388E 05	2.16E-03	1.22E 14	-0.
5	1.262E 06	5.816E 06	4.635E 06	6.773E-01	6.271E 02	1.475E 09	4.346E 09	0.	3.291E 05	4.33E-03	-4.05E 14	-0.

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
MATERIAL 1002												
6	3.291E 03	4.254E 06	1.399E 06	3.998E 00	1.203E 00	8.738E 05	3.243E 06	4.46E 05	3.822E 05	4.02E 00	6.43E 16	-0.
7	1.891E 03	3.812E 06	1.014E 06	5.035E 00	1.200E 00	7.627E 05	5.427E 01	5.92E 00	4.307E 05	3.50E 00	1.53E 17	-0.
8	1.923E 03	3.479E 06	9.620E 05	5.763E 00	1.200E 00	6.980E 05	2.939E 01	0.	4.729E 05	3.16E 00	1.43E 17	-0.
9	1.920E 03	3.174E 06	9.191E 05	6.342E 00	1.203E 00	6.481E 05	2.984E 01	0.	5.059E 05	2.88E 00	1.54E 17	-0.
10	1.951E 03	2.883E 06	8.798E 05	6.832E 00	1.200E 00	6.054E 05	3.028E 01	0.	5.268E 05	2.61E 00	1.12E 17	-0.
11	2.006E 03	2.586E 06	8.394E 05	7.299E 00	1.200E 00	5.648E 05	3.164E 01	0.	5.341E 05	2.34E 00	3.56E 16	-0.
12	2.110E 03	2.275E 06	7.937E 05	7.753E 00	1.200E 00	5.228E 05	3.424E 01	0.	5.245E 05	2.04E 00	-4.30E 16	-0.
13	2.225E 03	1.951E 06	7.386E 05	8.197E 00	1.200E 00	4.768E 05	3.798E 01	0.	4.996E 05	1.68E 00	-9.44E 16	-0.
14	2.071E 03	1.599E 06	6.612E 05	8.636E 00	1.200E 00	4.186E 05	3.644E 01	0.	4.682E 05	1.21E 00	-8.67E 16	1.31E 05
15	2.085E 02	7.525E 05	2.724E 05	9.073E 00	1.200E 00	1.603E 05	1.005E 01	1.64E 02	5.200E 02	4.60E-02	-4.93E 16	5.67E 12
16	5.956E-03	1.342E 02	7.496E 02	9.509E 00	1.200E 00	3.742E 01	8.788E-02	3.90E 00	5.423E-11	1.54E-04	-1.83E 11	1.29E-10
17	-1.607E-08	5.010E 01	2.930E 02	9.946E 00	1.200E 00	1.463E 01	7.173E-11	0.	0.	8.38E-08	-1.04E-05	0.
18	0.	5.010E 01	2.930E 02	1.039E 01	1.200E 00	1.463E 01	5.221E-22	0.	0.	8.38E-08	0.	0.
19	0.	5.010E 01	2.930E 02	1.083E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
20	0.	5.010E 01	2.930E 02	1.128E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
101	0.279051E-03	0.371699E-05	0.2241E-02	6	0.1941E-02	3	0.9390E 00	9	4	16	17	5
102	0.282768E-03	0.371699E-05	0.2283E-02	6	0.1884E-02	3	0.9300E 00	9	4	16	18	5

JV=16 NCUT=11 QVAR= 0.128751E 01 F= 0.245649E 02 FN= 0.696670E 01 VAR= 0.833322E 03 MF= 2 NV= 2

JV=16 NCUT=12 QVAR= 0.500999E 00 F= 0.245649E 02 FN= 0.456513E 02 VAR= 0.833322E 03 MF= 2 NV= 2

JV=16 NCUT=13 QVAR= 0.134049E 01 F= 0.245649E 02 FN= 0.726231E 01 VAR= 0.833322E 03 MF= 2 NV= 2

JV=16 NCUT=14 QVAR= 0.485956E 00 F= 0.245649E 02 FN= 0.470559E 02 VAR= 0.833322E 03 MF= 2 NV= 2

JV=16 NCUT=15 QVAR= 0.128287E 01 F= 0.245649E 02 FN= 0.694132E 01 VAR= 0.833322E 03 MF= 2 NV= 2

JV=16 NCUT=16 QVAR= 0.503827E 00 F= 0.245649E 02 FN= 0.455267E 02 VAR= 0.833322E 03 MF= 2 NV= 2

JV=16 NCUT=17 QVAR= 0.903723E 00 F= 0.245649E 02 FN= 0.234908E 02 VAR= 0.833322E 03 MF= 2 NV= 2

JV=16 NCUT=18 QVAR= 0.903621E 00 F= 0.245649E 02 FN= 0.245756E 02 VAR= 0.833322E 03 MF= 2 NV= 2

103	0.286485E-03	0.371699E-05	0.2325E-02	6	0.1828E-02	3	0.9211E 00	9	4	16	18	5
104	0.290202E-03	0.371699E-05	0.2368E-02	6	0.1774E-02	3	0.9122E 00	9	4	16	18	4
105	0.293919E-03	0.371699E-05	0.2411E-02	6	0.1720E-02	3	0.9034E 00	9	4	16	18	4
106	0.297636E-03	0.371699E-05	0.2454E-02	6	0.1668E-02	3	0.8947E 00	10	4	16	18	3
107	0.301353E-03	0.371699E-05	0.2497E-02	6	0.1618E-02	3	0.8896E 00	10	4	16	18	3
108	0.305070E-03	0.371699E-05	0.2858E-02	6	0.1985E-02	3	0.9950E 00	10	4	16	18	3
109	0.309251E-03	0.418162E-05	0.2910E-02	6	0.1917E-02	3	0.9890E 00	10	4	16	18	3
110	0.313433E-03	0.418162E-05	0.2966E-02	6	0.1851E-02	3	0.9829E 00	10	4	16	18	3

F	K	W	Y	W-Y+Y	JREG
0.426884E 00	0.202764E 00	0.629649E 00	0.276197E 00	0.905846E 00	5
0.276239E 00	0.886604E-01	0.364899E 00	0.654222E-06	0.887031E-01	90
0.703123E 00	0.291425E 00	0.994548E 00			

J	PVFLOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	C.	0.	0.	0.	0.	0.	C.	0.	0.	0.	-0.
MATERIAL 1000												
1	1.782E C5	1.302E 07	8.937F 06	3.538E-01	1.726E 03	8.227E 09	9.226E 07	0.	1.172E 05	3.35E-03	1.11E 15	-0.
2	3.C42F 05	1.158E 07	8.195E 06	4.454E-01	1.736E 03	7.519E 09	6.802F 08	0.	2.111F 05	2.27E-03	2.33E 15	-0.
3	5.282E 05	9.772E 06	7.136E 06	5.204E-01	1.453E 03	5.431E 09	1.696F 09	0.	2.435E 05	1.94E-03	8.37E 14	-0.
4	8.547E C5	7.541E C6	5.737E 06	6.C48E-01	9.528E 02	2.824E 09	3.C68E 09	0.	2.527E C5	2.65E-03	2.88E 14	-0.
5	1.327E 06	4.860E 06	4.013E C6	7.268E-01	4.699E 02	9.417E C8	3.766E 09	0.	2.267E C5	5.89E-03	-1.25E 15	-C.
MATERIAL 1C02												
6	4.388E C3	4.C39E 06	1.055E 06	3.998E 00	1.204E 00	8.179E 05	3.594E 06	6.13E 05	2.769E 05	3.74E 00	5.73E 16	-0.
7	2.058E 03	3.615E 06	9.825E 05	5.035E 00	1.200E 00	7.229E 05	8.396E 01	4.90F 01	3.225E 05	3.29E 00	1.45E 17	-0.
8	2.091F 03	3.305E 06	9.372E 05	5.763E 00	1.200E 00	6.687F C5	3.478E 01	0.	3.627E 05	2.99E 00	1.55E 17	-0.
9	2.094E 03	3.034E 06	9.001E 05	6.342E 00	1.200E 00	6.270E 05	3.539E 01	0.	3.956E 05	2.75E 00	1.56E 17	-0.
10	2.135E C3	2.782F 06	8.663E 05	6.832E 0C	1.200E C0	5.915E 05	3.614E 01	0.	4.198E 05	2.52E 00	1.25E 17	-0.
11	2.204E 03	2.532E 06	8.318E 05	7.300E 00	1.200E 00	5.576E 05	3.804E 01	0.	4.346E 05	2.29E 00	7.26E 16	-0.
12	2.332E C3	2.275E 06	7.937E 05	7.753E 00	1.200E 00	5.227E 05	4.157E 01	0.	4.353E 05	2.04E 00	3.01F 15	-0.
13	2.50CF 03	2.011E 06	7.497E 05	8.198E 00	1.200E 0C	4.856F 05	4.716E 01	0.	4.169E 05	1.75E 0C	-7.26E 15	-0.
14	2.655E C3	1.742E 06	6.957E 05	8.636E 0C	1.200E 00	4.438E C5	5.369E 01	0.	3.767E C5	1.42E 00	-1.30E 17	-0.
15	1.8C6E C3	1.434E 06	6.201E C5	9.C73E 00	1.200E 0C	3.897E 05	4.022E 01	2.72E 01	3.210E 05	9.89E-01	-1.26E 17	1.34E 05
16	6.789E C1	3.5C6E 05	1.259E 05	9.509E 00	1.200E 00	5.423E C4	7.097E 00	1.57E 02	2.731F 00	3.42E-03	-2.52E 15	2.78F 12
17	4.463E-04	5.112E C1	2.991E 02	9.946E 00	1.200E 00	1.493E 01	9.314E-03	6.95E-01	C.	9.88E-08	-5.17E 05	-2.69E-12
18	0.	5.010E C1	2.930E 02	1.C39E 01	1.200E 00	1.463E C1	4.025E-13	0.	0.	8.38E-08	0.	0.
19	0.	5.010E 01	2.930E C2	1.083E 01	1.200E C0	1.463E C1	0.	0.	0.	8.38E-08	0.	0.
20	0.	5.010E C1	2.930E 02	1.128E 01	1.200E 0C	1.463E 01	0.	0.	C.	8.38E-08	0.	0.
21	0.	5.010E 01	2.930E 02	1.174E 01	1.200E 00	1.463E 01	0.	0.	C.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
111	0.317614E-03	0.418162E-05	0.3022E-02	6	C.1787E-02	3	0.9770E 00	10	4	17	18	3
112	0.321796E-03	0.418162E-05	0.3078E-02	6	0.1725E-02	3	0.9712F 00	10	4	17	18	3
113	0.325978F-03	0.418162E-05	0.3135E-02	6	0.1665E-02	3	0.9656E 00	10	4	17	18	3
114	0.330159E-03	0.418162E-05	0.3192E-02	6	C.1608E-02	3	C.9598E 00	10	4	17	18	3
115	C.334341E-03	0.418162E-05	0.3250E-02	6	0.1552E-02	3	C.9542E 00	10	4	17	18	4
116	0.338523E-C3	C.418162E-05	0.3308E-02	6	0.1498E-02	3	0.9482E 00	10	4	17	18	5
117	C.342704E-03	C.418162E-05	0.3366E-02	6	C.1446E-02	3	0.9424E 00	10	4	17	19	6
118	C.346886E-03	0.418162E-05	0.3424E-02	6	0.1396E-02	3	0.9366E 0C	10	4	17	19	5
119	C.351067E-03	0.418162E-05	0.3484E-02	6	0.1362E-02	2	0.9308E 00	10	4	17	19	4
120	C.355249F-03	0.418162E-05	0.3544E-02	6	0.1333E-02	2	0.9248E 00	10	4	17	19	3

F	K	W	Y	W-Y+Y	JREG
0.377692E C0	0.236621E 00	0.614313E 00	0.284234E 00	C.898547F 0C	5
0.284304E C0	0.959218E-01	0.380226E 00	0.897927F-06	C.959927F-01	90
C.661556F C0	0.332543E 00	C.994539E 00			

J	PVFLOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	C.	0.	C.	0.	0.	-0.
MATERIAL 1000												
1	1.921E C5	1.204E 07	8.391E 06	3.616E-01	1.618E C3	7.203E 09	1.C06E 08	0.	9.791E 04	2.87E-03	7.78E 14	-0.
2	3.576E C5	1.041E 07	7.507E 06	4.593E-01	1.541E 03	6.C79E 09	7.842E 08	0.	1.623E 05	2.05E-03	1.35E 15	-0.
3	6.087F C5	8.476E 06	6.338E C6	5.444E-01	1.186E C3	3.908E C9	1.865E 09	0.	1.839E C5	2.1CE-03	5.34E 14	-C.
4	9.288E C5	6.348E 06	4.984E C6	6.423E-01	7.379E 02	1.878E 09	2.937E 09	0.	1.882E C5	3.52E-03	1.55E 14	-C.
5	1.38CE C6	4.127E 06	3.524E 06	7.836F-01	3.538E C2	6.117E 08	3.176F 09	0.	1.560E 05	7.45E-03	-1.72E 15	-0.

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMEP	NETPWR	RALORT
MATERIAL	1002											
6	5.939E 03	3.819E 06	1.016E 06	3.998E 00	1.206E 00	7.680E 05	3.901E 06	8.33E 05	2.025E 05	3.48E 00	5.04E 16	-0.
7	2.213E 03	3.415E 06	9.527E 05	5.035E 00	1.200E 00	6.870E 05	1.343E 02	2.01E 02	2.419E 05	3.10E 00	1.23E 17	-0.
8	2.246E 03	3.130E 06	9.131E 05	5.763E 00	1.200E 00	6.414E 05	4.018E 01	0.	2.798E 05	2.84E 00	1.40E 17	-0.
9	2.255E 03	2.890E 06	8.808E 05	6.342E 00	1.200E 00	6.064E 05	4.094E 01	0.	3.099E 05	2.62E 00	1.36F 17	-0.
10	2.304E 03	2.673E 06	8.514E 05	6.832E 00	1.200E 00	5.765E 05	4.199E 01	0.	3.339F 05	2.42F 00	1.19F 17	-0.
11	2.384E 03	2.462E 06	8.217E 05	7.300E 00	1.200E 00	5.480E 05	4.440E 01	0.	3.533F 05	2.73F 00	9.27F 16	-0.
12	2.528E 03	2.245E 06	7.891E 05	7.753E 00	1.200E 00	5.187E 05	4.876E 01	0.	3.664E 05	2.01E 00	5.79E 16	-0.
13	2.727E 03	2.022E 06	7.516E 05	8.198E 00	1.200E 00	4.872E 05	5.580E 01	0.	3.706E 05	1.77E 00	1.59F 16	-0.
14	2.956E 03	1.788E 06	7.059E 05	8.637F 00	1.200E 00	4.514E 05	6.526E 01	0.	3.600F 05	1.48E 00	-3.59E 16	-0.
15	3.133E 03	1.533E 06	6.435E 05	9.073E 00	1.200E 00	4.060E 05	7.494E 01	0.	3.135E 05	1.11E 00	-1.19E 17	-0.
16	1.092E 03	1.218E 06	5.328E 05	9.509E 00	1.200E 00	3.310E 05	3.609E 01	1.88F 02	1.093F 05	5.88E-01	-2.75E 17	1.29E [illegible]
17	3.047E 00	4.539E 04	3.401E 04	9.946E 00	1.200E 00	6.806E 03	2.425E 00	6.50E 01	3.724F-02	4.37E-03	-1.17E 15	1.87E 11
18	-1.511E-04	5.022E 01	2.937E 02	1.039E 01	1.200E 00	1.466E 01	1.875F-05	3.48E-01	0.	9.55E-08	-7.22F 23	2.57F-12
19	1.866E-04	5.010E 01	2.930E 02	1.083F 01	1.200E 00	1.463E 01	2.559F-15	0.	0.	9.38E-08	0.	0.
20	0.	5.010E 01	2.930E 02	1.128E 01	1.200E 00	1.463E 01	7.039E-14	0.	0.	9.38E-08	0.	0.
21	0.	5.010E 01	2.930E 02	1.174E 01	1.200E 00	1.463E 01	0.	0.	0.	9.38E-08	0.	0.
22	0.	5.010E 01	2.930E 02	1.220E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	J?	JSTAR	JHAT	IC
121	0.359431E-03	0.418162E-05	0.3602E-02	6	0.1304E-02	2	0.9189F 00	10	4	17	19	3
122	0.363612E-03	0.418162E-05	0.3663E-02	6	0.1275E-02	2	0.9131F 00	10	4	17	19	3
123	0.367794E-03	0.418162E-05	0.3724E-02	6	0.1246E-02	2	0.9073E 00	10	4	17	19	3
124	0.371976E-03	0.418162E-05	0.3784E-02	6	0.1218E-02	2	0.9019E 00	10	4	17	19	3
125	0.376157E-03	0.418162E-05	0.3847E-02	6	0.1190E-02	2	0.8963F 00	10	4	17	19	2
126	0.380339E-03	0.418162E-05	0.3907E-02	6	0.1163E-02	2	0.8910E 00	10	4	17	19	2
127	0.384520E-03	0.418162E-05	0.4466E-02	6	0.1438E-02	2	0.9967E 00	10	4	18	19	2
128	0.389225E-03	0.470432E-05	0.4541E-02	6	0.1400E-02	2	0.9901F 00	10	4	18	19	3
129	0.393929E-03	0.470432E-05	0.4620E-02	6	0.1364E-02	2	0.9840E 00	10	4	18	19	3
130	0.398633E-03	0.470432E-05	0.4700E-02	6	0.1327E-02	2	0.9778E 00	10	4	18	19	3

E	K	W	Y	W-Y+Y	JREG
0.334422E 00	0.268170E 00	0.602591E 00	0.289935E 00	0.892576E 00	5
0.290091E 00	0.101854E 00	0.391944E 00	0.100928E-05	0.101960E 00	.90
0.624512E 00	0.370023E 00	0.994535E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMEP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL	1000											
1	2.138E 05	1.109E 07	7.858E 06	3.704E-01	1.505E 03	6.244E 09	1.158E 08	0.	8.278F 04	2.54E-03	5.57E 14	-0.
2	4.153F 05	9.273E 06	6.826E 06	4.762E-01	1.337E 03	4.770E 09	8.914E 08	0.	1.279E 05	2.09E-03	9.53E 14	-0.
3	6.779E 05	7.308E 06	5.609E 06	5.725E-01	9.595E 02	2.774E 09	1.931E 09	0.	1.439E 05	2.52E-03	4.27E 14	-0.
4	9.873E 05	5.392E 06	4.371E 06	6.840E-01	5.774E 02	1.272E 09	2.696E 09	0.	1.391F 05	4.65F-03	-2.21E 14	-0.
5	1.422E 06	3.567E 06	3.141E 06	8.445E-01	2.709E 02	4.097E 08	2.649E 09	0.	1.092E 05	8.69E-03	-1.52E 15	-0.
MATERIAL	1002											
6	7.995E 03	3.608E 06	9.819E 05	3.998E 00	1.208E 00	7.265E 05	4.160E 06	1.10E 06	1.525F 05	3.25E 00	4.48E 16	-0.
7	2.350E 03	3.227E 06	9.264E 05	5.035E 00	1.200E 00	6.564E 05	2.163E 02	5.88E 02	1.897F 05	2.92E 00	1.35F 17	-0.
8	2.383E 03	2.968E 06	8.912E 05	5.763F 00	1.200E 00	6.174F 05	4.524E 01	0.	2.216F 05	2.69E 00	1.19F 17	-0.
9	2.396E 03	2.753E 06	8.623E 05	6.342E 00	1.200E 00	5.874E 05	4.614E 01	0.	2.483F 05	2.50E 00	1.15F 17	-0.
10	2.452E 03	2.563E 06	8.362E 05	6.832E 00	1.200E 00	5.617E 05	4.749F 01	0.	2.697E 05	2.32E 00	1.01E 17	-0.
11	2.542E 03	2.382E 06	8.100E 05	7.300E 00	1.200E 00	5.373F 05	5.040E 01	0.	2.869E 05	2.15F 00	7.92E 16	-0.
12	2.701E 03	2.199E 06	7.817E 05	7.753E 00	1.200E 00	5.123E 05	5.554E 01	0.	2.985E 05	1.96E 00	5.07E 16	-0.
13	2.921F 03	2.013E 06	7.501E 05	8.198E 00	1.200E 00	4.860E 05	6.386E 01	0.	3.036F 05	1.76E 00	1.96E 16	-0.
14	3.190E 03	1.824E 06	7.135E 05	8.637E 00	1.200E 00	4.571E 05	7.547E 01	0.	3.012F 05	1.52E 00	-8.40F 15	-0.
15	3.463E 03	1.625E 06	6.679E 05	9.073E 00	1.200E 00	4.234E 05	8.944F 01	0.	2.921F 05	1.25E 00	-2.59E 16	-0.
16	3.048E 03	1.397E 06	6.017E 05	9.509E 00	1.200E 00	3.772E 05	8.569E 01	2.09E 00	2.797F 05	8.95E-01	-2.55F 16	1.44E [illegible]
17	2.564E 02	5.969E 05	1.973E 05	9.946E 00	1.200E 00	1.077E 05	2.207E 01	3.73F 02	5.378E 01	1.36E-02	-8.71F 15	5.24E [illegible]
18	9.532E-03	6.543E 01	3.829E 02	1.039E 01	1.200E 00	1.912E 01	1.328E-01	5.89E 00	2.337E-14	7.14E-07	-8.71F 07	1.79E-11
19	1.866E-04	5.010E 01	2.930E 02	1.083E 01	1.200E 00	1.463E 01	1.909E-10	0.	0.	8.38E-08	-4.40E-09	0.
20	0.	5.010E 01	2.930E 02	1.128E 01	1.200E 00	1.463E 01	7.039E-14	0.	0.	8.38E-08	0.	0.
21	0.	5.010E 01	2.930E 02	1.174E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
22	0.	5.010E 01	2.930E 02	1.220E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
131	0.403338E-03	0.470432E-05	0.4781E-02	6	0.1292E-02	2	0.9719E 00	10	4	18	19	3

E	K	W	Y	W-Y+Y	JREG
0.330089E 00	0.271411E 00	0.601500E 00	0.290499E 00	0.891999E 00	5
0.290609E 00	0.102426E 00	0.393035E 00	0.103641E-05	0.102537E 00	90
0.620658E 00	0.373837E 00	0.994535E 00			

HISTORY EDIT AT CYCLE 131.

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	2.166E 05	1.099E 07	7.802E 06	3.714E-01	1.492E 03	6.146E 09	1.179E 08	0.	8.135E 04	2.51E-03	5.49E 14	-0.
2	4.215E 05	9.156E 06	6.755E 06	4.782E-01	1.316E 03	4.641E 09	9.023E 08	0.	1.249E 05	2.01E-03	8.19E 14	-0.
3	6.847E 05	7.192E 06	5.536E 06	5.757E-01	9.380E 02	2.674E 09	1.933E 09	0.	1.403E 05	2.58E-03	4.08E 14	-0.
4	9.928E 05	5.303E 06	4.313E 06	6.887E-01	5.629E 02	1.222E 09	2.667E 09	0.	1.346E 05	4.77E-03	-2.41E 14	-0.
5	1.426E 06	3.514E 06	3.105E 06	8.512E-01	2.636E 02	3.931E 08	2.557E 09	0.	1.051E 05	8.80E-03	-1.50E 15	-0.
MATERIAL 1002												
6	8.250E 03	3.586E 06	9.786E 05	3.998E 00	1.208E 00	7.225E 05	4.186E 06	1.13E 06	1.482E 05	3.23E 00	4.42E 15	-0.
7	2.363E 03	3.208E 06	9.238E 05	5.035E 00	1.200E 00	6.535E 05	2.277E 02	6.49E 02	1.848E 05	2.90E 00	1.03E 17	-0.
8	2.356E 03	2.951E 06	8.890E 05	5.763E 00	1.200E 00	6.150E 05	4.577E 01	0.	2.163E 05	2.68E 00	1.16E 17	-0.
9	2.410E 03	2.739E 06	8.604E 05	6.342E 00	1.200E 00	5.855E 05	4.668E 01	0.	2.476E 05	2.49E 00	1.13E 17	-0.
10	2.467E 03	2.552E 06	8.346E 05	6.832E 00	1.200E 00	5.602E 05	4.806E 01	0.	2.638E 05	2.31E 00	9.97E 16	-0.
11	2.558E 03	2.374E 06	8.088E 05	7.300E 00	1.200E 00	5.362E 05	5.102E 01	0.	2.810E 05	2.14E 00	7.89E 16	-0.
12	2.718E 03	2.194E 06	7.809E 05	7.753E 00	1.200E 00	5.116E 05	5.624E 01	0.	2.931E 05	1.96E 00	5.73E 16	-0.
13	2.940E 03	2.011E 06	7.457E 05	8.198E 00	1.200E 00	4.856E 05	6.469E 01	0.	2.992E 05	1.75E 00	2.38E 16	-0.
14	3.212E 03	1.824E 06	7.136E 05	8.637E 00	1.200E 00	4.572E 05	7.649E 01	0.	2.987E 05	1.53E 00	-1.55E 15	-0.
15	3.494E 03	1.627E 06	6.685E 05	9.073E 00	1.200E 00	4.238E 05	9.088E 01	0.	2.925E 05	1.25E 00	-1.78E 16	-0.
16	3.227E 03	1.400E 06	6.028E 05	9.509E 00	1.200E 00	3.779E 05	9.131E 01	0.	2.831E 05	9.00E-01	-1.93E 16	1.45E 25
17	3.279E 02	6.717E 05	2.302E 05	9.946E 00	1.200E 00	1.313E 05	2.555E 01	4.04E 02	1.700E 02	2.41E-02	-1.56E 18	6.25E 12
18	1.634E-02	9.249E 01	5.319E 02	1.039E 01	1.200E 00	2.655E 01	2.173E-01	8.28E 00	1.101E-12	9.89E-06	-3.81E 09	1.80E-12
19	1.866E-04	5.010E 01	2.930E 02	1.083E 01	1.200E 00	1.463E 01	5.522E-10	0.	0.	8.38E-08	-2.07E-07	0.
20	0.	5.010E 01	2.930E 02	1.128E 01	1.200E 00	1.463E 01	7.039E-14	0.	0.	8.38E-08	0.	0.
21	0.	5.010E 01	2.930E 02	1.174E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
22	0.	5.010E 01	2.930E 02	1.220E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

```
HISTORYS.
EVERY     50 CYCLES UNTIL CYCLE  5000
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0

PRINT OUTS.
EVERY    131 CYCLES UNTIL CYCLE   131
EVERY     29 CYCLES UNTIL CYCLE   160
EVERY     30 CYCLES UNTIL CYCLE  5000
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0

ENERGY CHECKS.
EVERY    131 CYCLES UNTIL CYCLE   131
EVERY     29 CYCLES UNTIL CYCLE   160
EVERY     30 CYCLES UNTIL CYCLE  5000
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
```

The problem has been restarted from the last cycle on the history tape (viz., N=131). The purpose of the change was to increase C5 from 1.5 to 10 in order to speed up the running time of the problem. C5 is the radiation diffusion stability criterion (GAMMA), and is used in TSRIMP.

```
RMIN=   0.

SPHERICAL GEOMETRY.

REGION     1. MATERIAL  1000.
C1=  0.6000E 01. C2=  0.5000E 00. C3=  0.1600E 01. C4=  0.2400E 02. C5=  0.1000E 02. F0= -0.1000E 01.
```

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	FL
1	0.1132E 00	0.5602E 02	0.7802E 03	0.6701E 00	0.4238E 05	0.4601E 05	0.1282E 07	0.1444E 07	0.7217E-03	0.2709E 05
2	0.1457E 00	0.1285E 03	0.6755E 03	0.7599E 00	0.3200E 05	0.3832E 05	0.1447E 07	0.1987E 07	0.7216E-03	0.416 E 05
3	0.1755E 00	0.2067E 03	0.5536E 03	0.1066E 01	0.1844E 05	0.3010E 05	0.1297E 07	0.2041E 07	0.7217E-03	0.4674E 05
4	0.2099E 00	0.3026E 03	0.4313E 03	0.1777E 01	0.8429E 04	0.2219E 05	0.1097E 07	0.1940E 07	0.7217E-03	0.4484E 05
5	0.2594E 00	0.4347E 03	0.3105E 03	0.3794E 01	0.2711E 04	0.1471E 05	0.1367E 06	0.3162E 07	0.7217E-03	0.3591E 05

```
REGION     2. MATERIAL  1002.
C1=  0.6000E 01. C2=  0.5000E 00. C3=  0.1600E 01. C4=  0.2400E 02. C5=  0.1000E 02. F0= -0.1000E 01.
```

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	EL
6	0.1219E 01	0.2515E 01	0.9786E 02	0.8277E 03	0.4983E 01	0.1501E 05	0.1168E 07	0.1172E 07	0.7218E-03	0.4935E 05
7	0.1535E 01	0.7204E 00	0.9238E 02	0.8332E 03	0.4507E 01	0.1343E 05	0.1293E 07	0.1293E 07	0.7219E-03	0.5156E 05
8	0.1757E 01	0.7304E 00	0.8890E 02	0.8335E 03	0.4242E 01	0.1235E 05	0.1399E 07	0.1399E 07	0.7219E-03	0.7235E 05
9	0.1933E 01	0.7347E 00	0.8604E 02	0.8335E 03	0.4034E 01	0.1146E 05	0.1505E 07	0.1505E 07	0.7219E-03	0.4081E 05
10	0.2082E 01	0.7519E 00	0.8346E 02	0.8334E 03	0.3863E 01	0.1068E 05	0.1621E 07	0.1621E 07	0.7219E-03	0.9784E 05
11	0.2225E 01	0.7797E 00	0.8088E 02	0.8334E 03	0.3698E 01	0.9935E 04	0.1762E 07	0.1762E 07	0.7241E-03	0.9358E 05
12	0.2365E 01	0.8284E 00	0.7809E 02	0.8334E 03	0.3528E 01	0.9181E 04	0.1945E 07	0.1945E 07	0.8735E-03	0.9762E 05

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	EL
13	0.2459E 01	0.8962E 00	0.7497E 02	0.8334E 03	0.3349E 01	0.8417E 04	0.2199E 07	0.2199E 07	0.9608E-03	0.9963E 05
14	0.2633E 01	0.9791E 00	0.7136E 02	0.8333E 03	0.3153E 01	0.7635E 04	0.2591E 07	0.2590E 07	0.1057E-02	0.9947E 05
15	0.2765E 01	0.1065E 01	0.6635E 02	0.8332E 03	0.2923E 01	0.6810E 04	0.3330E 07	0.3330E 07	0.1163E-02	0.9741E 05
16	0.2858E 01	0.9837E 00	0.6028E 02	0.8330E 03	0.2606E 01	0.5860E 04	0.7200E 07	0.7201E 07	0.1279E-02	0.9430E 05
17	0.3032E 01	0.4996E-01	0.2302E 02	0.8331E 03	0.9053E 00	0.2811E 04	0.2838E 09	0.2839E 09	0.1407E-02	0.5660E 02
18	0.3166E 01	0.4982E-05	0.5319E-01	0.8333E 03	0.1831E-03	0.3871E 00	0.1225E 13	0.1225E 13	0.1547E-02	0.3667E-12
19	0.3301E 01	0.5689E-07	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1702E-02	0.
20	0.3439E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1872E-02	0.
21	0.3578E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2060E-02	0.
22	0.3720E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2266E-02	0.
23	0.3864E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2492E-02	0.
24	0.4012E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2741E-02	0.
25	0.4162E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3016E-02	0.
26	0.4316E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3317E-02	0.
27	0.4473E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3649E-02	0.
28	0.4635E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4014E-02	0.
29	0.4800E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4415E-02	0.
30	0.4970E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4857E-02	0.
31	0.5144E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5342E-02	0.
32	0.5322E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5877E-02	0.
33	0.5506E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6464E-02	0.
34	0.5695E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7111E-02	0.
35	0.5889E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7822E-02	0.
36	0.6089E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8604E-02	0.
37	0.6295E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9464E-02	0.
38	0.6507E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1041E-01	0.
39	0.6725E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1145E-01	0.
40	0.6949E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1260E-01	0.
41	0.7181E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1386E-01	0.
42	0.7419E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1524E-01	0.
43	0.7665E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1677E-01	0.
44	0.7918E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1844E-01	0.
45	0.8179E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2029E-01	0.
46	0.8446E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2232E-01	0.
47	0.8725E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2455E-01	0.
48	0.9011E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2700E-01	0.
49	0.9306E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2970E-01	0.
50	0.9611E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3267E-01	0.
51	0.9925E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3594E-01	0.
52	0.1025E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3954E-01	0.
53	0.1058E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4349E-01	0.
54	0.1093E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4784E-01	0.
55	0.1128E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5262E-01	0.
56	0.1165E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5788E-01	0.
57	0.1203E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6367E-01	0.

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	FL
58	0.1242E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7004E-01	0.
59	0.1282E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7704E-01	0.
60	0.1324E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8475E-01	0.
61	0.1367E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9322E-01	0.
62	0.1411E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1025E 00	0.
63	0.1457E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1128E 00	0.
64	0.1504E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1241E 00	0.
65	0.1553E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1365E 00	0.
66	0.1603E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1501E 00	0.
67	0.1655E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1651E 00	0.
68	0.1708E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1817E 00	0.
69	0.1764E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1998E 00	0.
70	0.1821E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2198E 00	0.
71	0.1879E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2418E 00	0.
72	0.1940E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2660E 00	0.
73	0.2003E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2926E 00	0.
74	0.2068E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3218E 00	0.
75	0.2134E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3540E 00	0.
76	0.2203E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3894E 00	0.
77	0.2275E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4284E 00	0.
78	0.2348E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4712E 00	0.
79	0.2424E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5183E 00	0.
80	0.2502E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5701E 00	0.
81	0.2583E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6272E 00	0.
82	0.2667E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6899E 00	0.
83	0.2753E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7589E 00	0.
84	0.2842E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8347E 00	0.
85	0.2933E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9182E 00	0.
86	0.3028E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1010E 01	0.
87	0.3126E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1111E 01	0.
88	0.3227E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1222E 01	0.
89	0.3331E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1344E 01	0.
90	0.3439E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.	0.	0.1479E 01	0.

DT= 0.4704319E-05, DTP= 0.4704319E-05.

MASS ADD INFO.
JO= 4. JCS= 0. JOM= 80. DR= -0.3000000E-01.

PERCENTS.
X1= 0.2000E-05, X2= 0.8000E-05, X3= 0.4000E-05, X4= 0.2000E-05, X5= 0.1000E 00, X6= 0.2000E-03.

Z2= 0.2931000E-01, JHAT= 19, JL= 89, Z1= 0.3000000E-01, JSTAR= 18.

NF= 5000

NS= 131 IRAD= 7 10/7/66-HAR. TEST CASE 2-S.P.-IMP.

C1	C2	C3	C4	C5
0.6000E 01	0.5000E 00	0.1600E 01	0.2400E 02	0.1000E 02
0.6000E 01	0.5000E 00	0.1600E 01	0.2400E 02	0.1000E 02

JO	JOS	JOM	DRC
4	0	80	-0.3000E-01

Z1	Z2	JL	JHAT	JSTAR
0.3000E-01	0.2931E-01	89	19	18

X1	X2	X3	X4	X5	X6
0.2000E-05	0.8000E-05	0.4000E-05	0.2000E-05	0.1000E 00	0.2000E-03

RADIUS IS PRINTED IN FEET

PVELOC IS PRINTED IN FT/SEC

PRESUR IS PRINTED IN PSI

DENSTY IS PRINTED IN KG/M3

INTENG IS PRINTED IN CAL/GM

TEMP IS PRINTED IN KELVIN

DYNPRS IS PRINTED IN PSI

ARTVIS IS PRINTED IN PSI

LMNSTY IS PRINTED IN KT/SEC

ROSMFP IS PRINTED IN FEET

NETPWR IS PRINTED IN CAL/SC

RALORT IS PRINTED IN CAL/SC

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MATERIAL 1000												
1	2.166E 05	1.099E 07	7.802E 06	3.714E-01	1.492E 03	6.146E 09	1.179E 08	0.	4.135E 04	2.51E-03	5.49E 14	0.
2	4.215E 05	9.156E 06	6.755E 06	4.782E-01	1.316E 03	4.641E 09	9.023E 08	0.	1.249E 05	2.[illegible]E-03	9.19E 14	0.
3	6.647E 05	7.192E 06	5.536E 06	5.757E-01	9.380E 02	2.674E 09	1.935E 09	0.	1.403E 05	2.58E-03	4.[illegible]E 14	0.
4	9.928E 05	5.303E 06	4.313E 06	6.887E-01	5.629E 02	1.222E 09	2.667E 09	0.	1.346E 05	4.77E-03	-2.41E 14	0.
5	1.426E 06	3.514E 06	3.105E 06	8.512E-01	2.636E 02	3.931E 08	2.597E 09	0.	1.051E 05	8.90E-03	-1.50E 15	0.
MATERIAL 1002												
6	8.250E 03	3.586E 06	9.786E 05	3.998E 00	1.203E 00	7.225E 05	4.186E 06	1.13E 06	1.432E 05	3.23E 00	4.42E 16	0.
7	2.363E 03	3.208E 06	9.238E 05	5.035E 00	1.200E 00	6.535E 05	2.277E 02	6.49E 2	1.945E 05	2.95E 0[illegible]	1.13E 17	0.
8	2.396E 03	2.951E 06	6.890E 05	5.763E 00	1.200E 00	6.150E 05	4.577E 01	0.	2.163E 05	2.48E 00	1.16E 17	0.
9	2.410E 03	2.739E 06	8.604E 05	6.342E 00	1.200E 00	5.855E 05	4.668E 01	0.	2.426E 05	2.49E 00	1.13E 17	0.
10	2.467E 03	2.552E 06	8.346E 05	6.632E 00	1.200E 00	5.602E 05	4.806E 01	0.	2.639E 05	2.31E 00	9.97E 16	0.
11	2.556E 03	2.374E 06	8.088E 05	7.300E 00	1.200E 00	5.362E 05	5.102E 01	0.	2.81[illegible] 05	2.14E 00	7.89E 16	0.
12	2.718E 03	2.194E 06	7.809E 05	7.753E 00	1.200E 00	5.116E 05	5.624E 01	0.	2.931E 05	1.96E 00	5.23E 15	0.
13	2.940E 03	2.011E 06	7.497E 05	8.198E 00	1.200E 00	4.856E 05	6.469E 01	0.	2.992E 05	1.75E 00	2.38E 16	0.
14	3.212E 03	1.824E 06	7.136E 05	8.637E 00	1.200E 00	4.572E 05	7.549E 01	0.	2.99[illegible] 05	1.57E 00	-1.65E 15	0.
15	3.494E 03	1.627E 06	6.685E 05	9.073E 00	1.200E 00	4.238E 05	9.088E 01	0.	2.925E 05	1.25E 00	-1.78E 16	0.
16	3.227E 03	1.400E 06	6.028E 05	9.509E 00	1.200E 00	3.779E 05	9.131E 01	0.	2.831E 05	9.20E-01	-1.93E 15	0.
17	3.279E 02	6.717E 05	2.302E 05	9.946E 00	1.203E 00	1.313E 05	2.555E 01	4.[illegible]4E 02	1.7[illegible]	2.41E-02	-1.56E 15	0.

J	RVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
18	1.634E-02	5.249E 01	5.319E 02	1.039E 01	1.200E 00	2.555E 01	2.173E-01	8.285 00	1.101E-12	9.39E-06	-3.81E 09	0.
19	1.866E-04	5.010E 01	2.930E 02	1.043E 01	1.200E 00	1.463E 01	5.522E-10	0.	0.	8.38E-08	-2.07E-07	0.
20	0.	5.010E 01	2.930E 02	1.128E 01	1.200E 00	1.463E 01	7.039E-14	0.	0.	8.38E-08	0.	0.
21	0.	5.010E 01	2.930E 02	1.174E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
22	0.	5.010E 01	2.930E 02	1.220E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
132	0.406042E-03	0.470432E-05	0.5469E-02	6	0.1591E-02	2	0.5625E 00	1	4	18	19	3
133	0.413334E-03	0.529230E-05	0.6262E-02	6	0.1953E-02	2	0.5625E 00	1	4	18	19	4
134	0.419236E-03	0.595390E-05	0.7135E-02	6	0.2388E-02	2	0.5625E 00	1	4	18	20	4
135	0.425586E-03	0.669814E-05	0.8261E-02	6	0.2906E-02	2	0.5625E 00	1	4	18	20	4
136	0.433522E-03	0.753541E-05	0.9522E-02	6	0.3518E-02	2	0.5625E 00	1	4	18	20	4
137	0.441950E-03	0.847734E-05	0.1100E-01	6	0.4235E-02	2	0.5625E 00	1	4	18	20	4
138	0.451536E-03	0.953730E-05	0.1275E-01	6	0.5065E-02	2	0.5625E 00	1	4	18	20	4
139	0.462265E-03	0.107291E-04	0.1482E-01	6	0.6015E-02	2	0.5625E 00	1	4	18	20	3
140	0.474355E-03	0.120703E-04	0.1729E-01	6	0.7287E-02	2	0.5625E 00	1	4	19	20	3
141	0.487915E-03	0.135791E-04	0.2024E-01	6	0.8277E-02	2	0.5625E 0	1	4	19	20	3
142	0.503191E-03	0.152764E-04	0.2377E-01	6	0.9576E-02	2	0.5625E 00	1	4	19	20	4
143	0.520377E-03	0.171860E-04	0.2804E-01	6	0.1097E-01	2	0.5625E 00	1	4	19	20	5
144	0.539711E-03	0.193342E-04	0.3322E-01	6	0.1242E-01	2	0.5752E 00	10	4	19	21	7
145	0.561462E-03	0.217510E-04	0.3953E-01	6	0.1391E-01	2	0.6331E 00	10	4	19	21	5
146	0.585932E-03	0.244697E-04	0.4724E-01	6	0.1539E-01	2	0.6958E 00	11	4	19	21	4
147	0.613401E-03	0.275285E-04	0.5674E-01	6	0.1682E-01	2	0.7656E 00	11	4	20	21	3
148	0.644430E-03	0.309697E-04	0.6846E-01	6	0.1815E-01	2	0.8408E 00	11	4	20	21	4
149	0.679271E-03	0.348409E-04	0.8300E-01	6	0.1934E-01	2	0.9217E 00	11	4	20	22	7

JV=20 NCOT=11 OVAR= 0.128565E 01 F= 0.242560E 02 FN= 0.703592E 01 VAR= 0.833125E 03 MF= 2 NV= 2

JV=20 NCOT=12 OVAR= 0.490976E 00 F= 0.242560E 02 FN= 0.456009E 02 VAR= 0.833125E 03 MF= 2 NV= 2

JV=20 NCOT=13 OVAR= 0.128838E 01 F= 0.242560E 02 FN= 0.705087E 01 VAR= 0.833125E 03 MF= 2 NV= 2

JV=20 NCOT=14 OVAR= 0.489014E 00 F= 0.242560E 02 FN= 0.456743E 02 VAR= 0.833125E 03 MF= 2 NV= 2

JV=20 NCOT=15 OVAR= 0.128322E 01 F= 0.242560E 02 FN= 0.702137E 01 VAR= 0.833125E 03 MF= 2 NV= 2

JV=20 NCOT=16 OVAR= 0.492145E 00 F= 0.242560E 02 FN= 0.455357E 02 VAR= 0.833125E 03 MF= 2 NV= 2

JV=20 NCOT=17 OVAR= 0.900703E 00 F= 0.242560E 02 FN= 0.229065E 02 VAR= 0.833125E 03 MF= 2 NV= 2

JV=20 NCOT=18 OVAR= 0.900701E 00 F= 0.242560E 02 FN= 0.242772E 02 VAR= 0.833125E 03 MF= 2 NV= 2

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
150	0.718467E-03	0.391960E-04	0.8989E-01	6	0.1628E-01	1	0.8951E 00	11	4	21	22	7

HISTORY EDIT AT CYCLE 150.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
151	0.757663E-03	0.391960E-04	0.1094E 00	6	0.1761E-01	1	0.9787E 00	11	4	21	22	4
152	0.801759E-03	0.440955E-04	0.1185E 00	6	0.1475E-01	1	0.9490E 00	11	4	21	22	3
153	0.845854E-03	0.440955E-04	0.1281E 00	6	0.1237E-01	1	0.9219E 00	11	4	21	22	3
154	0.889950E-03	0.440955E-04	0.1379E 00	6	0.1039E-01	1	0.8967E 00	11	4	21	22	4
155	0.934046E-03	0.440955E-04	0.1663E 00	6	0.1108E-01	1	0.9623E 00	11	4	22	23	9
156	0.983653E-03	0.496075E-04	0.1784E 00	6	0.9158E-02	1	0.9539E 00	11	4	22	23	5
157	0.103326E-02	0.496075E-04	0.1914E 00	6	0.7598E-02	1	0.9277E 00	11	4	22	23	4
158	0.108287E-02	0.496075E-04	0.2045E 00	6	0.6326E-02	1	0.9042E 00	11	4	22	23	3
159	0.113248E-02	0.496075E-04	0.2450E 00	6	0.6630E-02	1	0.9932E 00	11	4	22	23	3
160	0.118328E-02	0.558084E-04	0.2613E 00	6	0.5489E-02	1	0.9695E 00	11	4	22	23	3

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMEP	NETPWR	RALORT

F	K	W	Y	W-Y+Y	JREG
0.584507E-01	0.494097E 00	0.552547E 00	0.305429E 00	0.857976E 00	5
0.312125E 00	0.129530E 00	0.441661E 00	0.490001E-05	0.136237E 00	90
0.370576E 00	0.623632E 00	0.994208E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMEP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	5.920E 05	1.912E 06	2.049E 05	7.294E-01	1.970E 02	1.728E 08	1.163E 08	0.	1.267E 03	3.44E-03	5.98E 12	-0.
2	8.115E 05	1.493E 06	1.702E 06	1.023E 00	1.122E 02	7.562E 07	3.722E 08	0.	1.479E 03	4.01E-03	2.96E 12	-0.
3	1.022E 06	1.171E 06	1.427E 06	1.302E 00	6.725E 01	3.454E 07	3.809E 08	0.	1.317E 03	4.41E-03	-2.57E 12	-0.
4	1.264E 06	9.042E 05	1.184E 06	1.620E 00	3.739E 01	1.406E 07	3.770E 08	0.	1.154E 03	5.22E-03	-2.67E 12	-0.
5	1.585E 06	6.447E 05	9.282E 05	2.071E 00	1.651E 01	3.976E 06	2.257E 08	0.	1.766E 03	7.19E-03	-1.40E 12	-0.
MATERIAL 1002												
6	1.682E 05	2.057E 06	7.626E 05	4.054E 00	1.324E 00	5.455E 05	6.858E 04	9.54E 06	2.430E 04	1.56E 00	1.83E 15	-0.
7	1.202E 04	1.896E 06	7.298E 05	5.039E 00	1.247E 00	4.877E 05	6.821E 04	7.09E 05	2.936E 04	1.53E 00	7.84E 15	-0.
8	3.536E 03	1.807E 06	7.099E 05	5.765E 00	1.201E 00	4.547E 05	4.894E 02	2.09E 03	3.277E 04	1.50E 00	7.06E 15	-0.
9	3.595E 03	1.739E 06	6.951E 05	6.345E 00	1.199E 00	4.429E 05	1.027E 02	0.	3.616E 04	1.41E 00	8.27E 15	-0.
10	3.725E 03	1.685E 06	6.827E 05	6.834E 00	1.199E 00	4.336E 05	1.081E 02	0.	3.945E 04	1.34E 00	9.01E 15	-0.
11	3.906E 03	1.637E 06	6.709E 05	7.302E 00	1.199E 00	4.250E 05	1.175E 02	0.	4.288E 04	1.27E 00	9.32E 15	-0.
12	4.176E 03	1.590E 06	6.588E 05	7.756E 00	1.199E 00	4.163E 05	1.318E 02	0.	4.638E 04	1.20E 00	9.25E 15	-0.
13	4.544E 03	1.543E 06	6.461E 05	8.201E 00	1.198E 00	4.073E 05	1.534E 02	0.	4.985E 04	1.13E 00	8.84E 15	-0.
14	5.023E 03	1.496E 06	6.326E 05	8.640E 00	1.198E 00	3.977E 05	1.847E 02	0.	5.322E 04	1.06E 00	8.12E 15	-0.
15	5.640E 03	1.447E 06	6.177E 05	9.077E 00	1.198E 00	3.874E 05	2.294E 02	0.	5.641E 04	9.79E-01	7.14E 15	-0.
16	6.445E 03	1.395E 06	6.010E 05	9.513E 00	1.198E 00	3.759E 05	2.946E 02	0.	5.932E 04	8.94E-01	5.96E 15	-0.
17	7.516E 03	1.340E 06	5.817E 05	9.951E 00	1.198E 00	3.629E 05	3.932E 02	0.	6.190E 04	8.[illegible]1E-01	4.54E 15	-0.
18	8.928E 03	1.279E 06	5.583E 05	1.039E 01	1.199E 00	3.474E 05	5.458E 02	0.	6.381E 04	6.95E-01	3.17E 15	-0.
19	1.075E 04	1.266E 06	5.277E 05	1.084E 01	1.201E 00	3.277E 05	7.830E 02	0.	6.535E 04	5.68E-01	1.97E 15	[illegible]
20	1.025E 04	1.108E 06	4.804E 05	1.128E 01	1.205E 00	2.979E 05	8.955E 02	0.	6.627E 04	4.02E-01	8.26E 1[illegible]	1.41E [illegible]
21	8.741E 02	5.094E 05	1.665E 05	1.174E 01	1.205E 00	3.521E 04	2.512E 02	4.01E 03	2.163E 01	7.52E-03	-1.09E 15	5.25E 12
22	1.591E-01	8.367E 01	4.844E 02	1.220E 01	1.209E 00	2.418E 01	1.545E 00	4.53E 01	4.797E-13	4.68E-06	-2.18E 08	3.91E-11
23	1.796E-04	5.010E 01	2.930E 02	1.268E 01	1.200E 00	1.463E 01	5.127E-08	0.	0.	8.38E-08	-8.49E-09	0.
24	0.	5.010E 01	2.930E 02	1.316E 01	1.200E 00	1.463E 01	6.521E-14	0.	0.	8.38E-08	0.	0.
25	0.	5.010E 01	2.930E 02	1.366E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
26	0.	5.010E 01	2.930E 02	1.416E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JC	JSTAR	JHAT	IC
161	0.124409E-02	0.558084E-04	0.2747E 00	6	0.4524E-02	1	0.9489E 00	11	4	22	23	4
162	0.129990E-02	0.558084E-04	0.2962E 00	6	0.3745E-02	1	0.9307E 00	11	4	22	24	5
163	0.135571E-02	0.558084E-04	0.3138E 00	6	0.3115E-02	1	0.9154E 00	11	4	22	24	5
164	0.141152E-02	0.558034E-04	0.3316E 00	6	0.2613E-02	2	0.9126E 00	11	4	22	24	4
165	0.146733E-02	0.558084E-04	0.3493E 00	6	0.2219E-02	2	0.8923E 00	11	4	22	24	4
166	0.152313E-02	0.558084E-04	0.4130E 00	6	0.2396E-02	2	0.9954E 00	11	4	23	24	3
167	0.158592E-02	0.627845E-04	0.4345E 00	6	0.2015E-02	2	0.9895E 00	11	4	23	24	3
168	0.164870E-02	0.627845E-04	0.4567E 00	6	0.1704E-02	2	0.9868E 00	11	4	23	24	3
169	0.171149E-02	0.627845E-04	0.4785E 00	6	0.1450E-02	2	0.9872E 00	11	4	23	24	3
170	0.177427E-02	0.627845E-04	0.4997E 00	6	0.1240E-02	2	0.9899E 00	11	4	23	24	3
171	0.183706E-02	0.627845E-04	0.5201E 00	6	0.1065E-02	2	0.9956E 00	12	4	23	24	3
172	0.189984E-02	0.627845E-04	0.4797E 00	6	0.7271E-03	2	0.8918E 00	12	4	23	24	5
173	0.195565E-02	0.558084E-04	0.4949E 00	6	0.6844E-03	13	0.8983E 00	12	4	23	25	5
174	0.201146E-02	0.558084E-04	0.5089E 00	6	0.6856E-03	13	0.9049E 00	12	4	24	25	4
175	0.206727E-02	0.558084E-04	0.5221E 00	6	0.6870E-03	13	0.9118E 00	12	4	24	25	5
176	0.212307E-02	0.558084E-04	0.5347E 00	6	0.6884E-03	13	0.9185E 00	10	4	24	25	4
177	0.217888E-02	0.558084E-04	0.5466E 00	6	0.6898E-03	13	0.9247E 00	10	4	24	25	3
178	0.223469E-02	0.558084E-04	0.5578E 00	6	0.6913E-03	13	0.9304E 00	10	4	24	25	3
179	0.229050E-02	0.558084E-04	0.5683E 00	6	0.6928E-03	13	0.9361E 00	10	4	24	25	3
180	0.234631E-02	0.558084E-04	0.5782E 00	6	0.6942E-03	13	0.9410E 00	10	4	24	25	3
181	0.240212E-02	0.558084E-04	0.5875E 00	6	0.6956E-03	13	0.9456E 00	10	4	24	25	3

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
182	0.245792E-02	0.558084E-04	0.5961E 00	6	0.6969E-03	13	0.9501E 00	11	4	24	25	3
183	0.251373E-02	0.558084E-04	0.6042E 00	6	0.6981E-03	13	0.9546E 00	11	4	24	25	3
184	0.256954E-02	0.558084E-04	0.6117E 00	7	0.6992E-03	13	0.9583E 00	11	4	24	25	3
185	0.262535E-02	0.558084E-04	0.6252E 00	7	0.7001E-03	13	0.9619E 00	11	4	24	25	3
186	0.268116E-02	0.558084E-04	0.6383E 00	7	0.7109E-03	13	0.9646E 00	11	4	24	25	4
187	0.273697E-02	0.558084E-04	0.6510E 00	7	0.7431E-03	7	0.9672E 00	11	4	24	25	4
188	0.279278E-02	0.558084E-04	0.6633E 00	7	0.7947E-03	7	0.9687E 00	11	4	24	26	4

JV=24 NCOT=11 OVAR= 0.870153E 00 F= 0.211447E 02 FN= 0.212275E 02 VAR= 0.829942E 03 MF= 2 NV= 2

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
189	0.284858E-02	0.558084E-04	0.6753E 00	7	0.8509E-03	7	0.9698E 00	11	4	25	26	4
190	0.290439E-02	0.558084E-04	0.6869E 00	7	0.9122E-03	7	0.9704E 00	11	4	25	26	5

E	K	W	Y	W-Y+Y	JREG
0.154166E-01	0.464082E 00	0.479499E 00	0.301313E 00	0.780812E 00	5
0.388799E 00	0.125640E 03	0.514440E 00	0.163663E-04	0.213143E 03	90
0.404216E 00	0.583723E 00	0.993939E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARIVIS	LMNSTY	ROSMFP	NETPWR	RALPRT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	6.559E 05	2.904E 05	5.743E 05	1.831E 00	1.246E 01	1.127E 06	9.027E 06	0.	5.696E 00	2.26E-03	7.26E 09	-0.
2	8.702E 05	2.760E 05	5.427E 05	2.491E 00	8.196E 00	6.593E 05	3.214E 07	0.	2.705E 01	3.61E-03	8.32E 11	-0.
3	1.070E 06	2.549E 05	5.023E 05	3.118E 00	5.146E 00	3.527E 05	3.261E 07	0.	-1.814E 02	5.90E-03	-1.91E 12	-0.
4	1.293E 06	3.472E 05	5.845E 05	3.632E 00	2.948E 00	2.800E 05	2.771E 07	0.	-3.154E 03	2.06E-02	-8.45E 13	-0.
5	1.102E 06	5.246E 05	7.381E 05	4.432E 00	2.483E 00	3.875E 05	2.397E 07	0.	-3.633E 03	5.54E-02	-4.42E 13	-0.
MATERIAL 1002												
6	6.889E 05	1.910E 06	7.639E 05	4.901E 00	2.495E 00	1.010E 06	1.347E 07	5.09E 06	1.615E 04	4.93E-01	2.07E 16	-0.
7	3.725E 05	1.860E 06	7.484E 05	5.336E 00	2.234E 00	8.849E 05	4.237E 06	4.45E 06	3.598E 04	5.73E-01	2.52E 16	-0.
8	1.397E 05	1.810E 06	7.241E 05	5.835E 00	1.636E 00	6.285E 05	7.225E 05	2.24E 06	4.710E 04	9.21E-01	2.05E 16	-0.
9	2.404E 04	1.756E 06	7.026E 05	6.357E 00	1.312E 00	4.897E 05	5.922E 04	5.46E 05	5.009E 04	1.26E 00	7.20E 15	-0.
10	6.305E 03	1.697E 06	6.857E 05	6.843E 00	1.205E 00	4.382E 05	1.870E 03	1.19E 04	5.048E 04	1.35E 00	1.26E 15	-0.
11	6.264E 03	1.637E 06	6.708E 05	7.311E 00	1.195E 00	4.237E 05	3.181E 02	0.	5.050E 04	1.28E 00	7.34E 13	-0.
12	6.545E 03	1.582E 06	6.566E 05	7.765E 00	1.194E 00	4.133E 05	3.300E 02	0.	5.043E 04	1.20E 00	-1.75E 14	-0.
13	6.955E 03	1.531E 06	6.425E 05	8.211E 00	1.194E 00	4.032E 05	3.665E 02	0.	5.026E 04	1.12E 00	-4.31E 14	-0.
14	7.524E 03	1.482E 06	6.284E 05	8.651E 00	1.193E 00	3.931E 05	4.213E 02	0.	4.999E 04	1.04E 00	-6.42E 14	-0.
15	8.280E 03	1.436E 06	6.140E 05	9.089E 00	1.192E 00	3.828E 05	5.012E 02	0.	4.961E 04	9.69E-01	-8.30E 14	-0.
16	9.291E 03	1.390E 06	5.991E 05	9.527E 00	1.190E 00	3.722E 05	6.189E 02	0.	4.913E 04	3.94E-01	-9.92E 14	-0.
17	1.066E 04	1.345E 06	5.832E 05	9.966E 00	1.189E 00	3.611E 05	7.963E 02	0.	4.852E 04	8.19E-01	-1.13E 15	-0.
18	1.253E 04	1.299E 06	5.659E 05	1.041E 01	1.187E 00	3.490E 05	1.074E 03	0.	4.776E 04	7.41E-01	-1.25E 15	-0.
19	1.517E 04	1.251E 06	5.465E 05	1.086E 01	1.185E 00	3.358E 05	1.530E 03	0.	4.680E 04	6.58E-01	-1.41E 15	-0.
20	1.901E 04	1.199E 06	5.239E 05	1.131E 01	1.184E 00	3.209E 05	2.330E 03	0.	4.549E 04	5.67E-01	-1.64E 15	-0.
21	2.447E 04	1.138E 06	4.957E 05	1.177E 01	1.193E 00	3.048E 05	3.796E 03	0.	4.340E 04	4.59E-01	-2.09E 15	-0.
22	2.820E 04	1.059E 06	4.552E 05	1.222E 01	1.226E 00	2.863E 05	5.726E 03	0.	3.883E 04	3.19E-01	-3.22E 15	-0.
23	9.514E 03	9.137E 05	3.657E 05	1.269E 01	1.241E 00	2.323E 05	2.971E 03	1.52E 04	1.033E 04	1.42E-01	-8.93E 15	9.57E 12
24	7.037E 01	1.913E 04	2.101E 04	1.316E 01	1.206E 00	2.515E 03	1.866E 02	4.15E 03	3.512E-02	1.22E-02	-2.54E 14	9.49E 0?
25	1.346E-02	5.174E 01	3.028E 02	1.366E 01	1.200E 00	1.512E 01	1.001E-02	1.12E 00	7.850E-16	1.39E-07	-7.76E 03	7.47E-1?
26	-7.627E-06	5.010E 01	2.930E 02	1.416E 01	1.200E 00	1.463E 01	3.559E-10	4.89E-02	0.	8.36E-08	-1.31E-13	0.
27	0.	5.010E 01	2.930E 02	1.468E 01	1.200E 00	1.463E 01	1.175E-16	0.	0.	8.38E-08	0.	0.
28	0.	5.010E 01	2.930E 02	1.521E 01	1.200E 00	1.463E 01	0.	0.	0.	8.39E-08	0.	0.
29	0.	5.010E 01	2.930E 02	1.575E 01	1.200E 00	1.463E 01	0.	0.	0.	8.36E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
191	0.296020E-02	0.558084E-04	0.6982E 00	7	0.9790E-03	7	0.9703E 00	11	4	25	26	4
192	0.301601E-02	0.558084E-04	0.7091E 00	7	0.1052E-02	7	0.9699E 00	11	4	25	26	3
193	0.307182E-02	0.558084E-04	0.7198E 00	7	0.1131E-02	7	0.9688E 00	11	4	25	26	3
194	0.312765E-02	0.558084E-04	0.7302E 00	7	0.1218E-02	7	0.9677E 00	11	4	25	26	3
195	0.318343E-02	0.558084E-04	0.7403E 00	7	0.1313E-02	7	0.9663E 00	11	4	25	26	3
196	0.323924E-02	0.558084E-04	0.7501E 00	7	0.1417E-02	7	0.9645E 00	11	4	25	26	3
197	0.329505E-02	0.558084E-04	0.7597E 00	7	0.1531E-02	7	0.9624E 00	11	4	25	26	3

E	K	W	Y	W-Y+Y	JREG
0.149220E-01	0.451397E 00	0.466319E 00	0.299924E 00	0.766243E 00	5
0.404866E 00	0.122617E 00	0.527484E 00	0.175806E-04	0.227577E 00	90
0.419788E 00	0.574014E 00	0.993803E 00			

HISTORY EDIT AT CYCLE 197.

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	DNVSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	6.574E 05	2.393E 05	4.993E 05	2.087E 00	8.407E 00	5.677E 05	6.118E 06	0.	4.031E 00	2.78E-03	5.37E 09	-0.
2	8.719E 05	2.317E 05	4.767E 05	2.832E 00	5.616E 00	3.448E 05	2.212E 07	0.	4.040E 00	4.53E-03	3.53E 08	-0.
3	1.070E 06	2.380E 05	4.702E 05	3.536E 00	3.553E 00	2.127E 05	2.256E 07	0.	-9.133E 02	8.71E-03	-1.13E 13	-0.
4	1.290E 06	4.192E 05	6.395E 05	4.336E 00	2.049E 00	2.374E 05	1.923E 07	0.	-3.963E 03	4.66E-02	-1.78E 14	-0.
5	9.813E 05	5.160E 05	7.300E 05	4.835E 00	2.428E 00	3.707E 05	2.110E 07	3.11E 05	-3.187E 03	5.53E-02	8.50E 13	-0.
MATERIAL 1002												
6	6.904E 05	1.800E 06	7.479E 05	5.172E 00	3.015E 00	1.186E 06	1.429E 07	3.37E 06	9.918E 03	3.31E-01	1.28E 16	-0.
7	4.401E 05	1.773E 06	7.378E 05	5.497E 00	2.755E 00	1.069E 06	5.991E 06	3.73E 06	2.640E 04	3.77E-01	1.91E 16	-0.
8	2.110E 05	1.754E 06	7.181E 05	5.906E 00	1.920E 00	7.277E 05	1.371E 06	2.52E 06	3.910E 04	6.74E-01	2.10E 16	-0.
9	5.949E 04	1.720E 06	6.984E 05	6.374E 00	1.443E 00	5.333E 05	1.776E 05	9.92E 05	4.464E 04	1.04E 00	1.23E 15	-0.
10	9.272E 03	1.678E 06	6.823E 05	6.846E 00	1.237E 00	4.468E 05	9.847E 03	1.03E 05	4.594E 04	1.27E 00	3.51E 15	-0.
11	6.805E 03	1.627E 06	6.683E 05	7.314E 00	1.195E 00	4.220E 05	5.201E 02	1.14E 02	4.637E 04	1.26E 00	1.15E 15	-0.
12	7.079E 03	1.576E 06	6.550E 05	7.768E 00	1.193E 00	4.118E 05	3.873E 02	0.	4.667E 04	1.19E 00	7.78E 14	-0.
13	7.499E 03	1.528E 06	6.419E 05	8.214E 00	1.192E 00	4.023E 05	4.267E 02	0.	4.687E 04	1.12E 00	5.02E 14	-0.
14	8.077E 03	1.483E 06	6.288E 05	8.654E 00	1.191E 00	3.929E 05	4.867E 02	0.	4.696E 04	1.05E 00	2.12E 14	-0.
15	8.855E 03	1.440E 06	6.154E 05	9.092E 00	1.190E 00	3.832E 05	5.745E 02	0.	4.692E 04	9.78E-01	-9.04E 13	-0.
16	9.896E 03	1.398E 06	6.015E 05	9.530E 00	1.188E 00	3.733E 05	7.036E 02	0.	4.672E 04	9.09E-01	-4.01E 14	-0.
17	1.130E 04	1.355E 06	5.869E 05	9.971E 00	1.186E 00	3.629E 05	8.974E 02	0.	4.635E 04	8.40E-01	-7.15E 14	-0.
18	1.322E 04	1.313E 06	5.713E 05	1.042E 01	1.184E 00	3.517E 05	1.199E 03	0.	4.576E 04	7.69E-01	-1.03E 15	-0.
19	1.593E 04	1.270E 06	5.542E 05	1.086E 01	1.181E 00	3.397E 05	1.690E 03	0.	4.490E 04	6.95E-01	-1.32E 15	-0.
20	1.978E 04	1.224E 06	5.349E 05	1.132E 01	1.179E 00	3.266E 05	2.532E 03	0.	4.374E 04	6.15E-01	-1.57E 15	-0.
21	2.518E 04	1.173E 06	5.122E 05	1.178E 01	1.186E 00	3.136E 05	4.037E 03	0.	4.221E 04	5.22E-01	-1.73E 15	-0.
22	2.940E 04	1.112E 06	4.832E 05	1.223E 01	1.220E 00	3.034E 05	6.120E 03	0.	4.040E 04	4.02E-01	-1.61E 15	-0.
23	2.169E 04	1.030E 06	4.392E 05	1.269E 01	1.252E 00	2.814E 05	5.504E 03	1.81E 03	3.868E 04	2.69E-01	-1.02E 15	1.85E 05
24	1.597E 03	3.437E 05	1.246E 05	1.316E 01	1.221E 00	5.414E 04	1.116E 03	1.35E 04	4.393E 00	3.24E-03	-2.64E 14	5.54E 12
25	1.116E 00	2.306E 01	3.094E 02	1.366E 01	1.201E 00	1.845E 01	5.164E 00	1.35E 02	2.308E-14	5.35E-07	-4.76E 06	5.11E-11
26	3.230E-04	5.010E 01	2.930E 02	1.416E 01	1.200E 00	1.463E 01	2.520E-06	0.	0.	8.38E-08	-3.83E-09	0.
27	0.	5.010E 01	2.930E 02	1.468E 01	1.200E 00	1.463E 01	2.108E-13	0.	0.	8.38E-08	0.	0.
28	0.	5.010E 01	2.930E 02	1.521E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
29	0.	5.010E 01	2.930E 02	1.575E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

```
HISTORYS.
EVERY     50 CYCLES UNTIL CYCLE  5C00
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0

PRINT OUTS.
EVERY    131 CYCLES UNTIL CYCLE   131
EVERY     29 CYCLES UNTIL CYCLE   160
EVERY     30 CYCLES UNTIL CYCLE  5C00
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0

ENERGY CHECKS.
EVERY    131 CYCLES UNTIL CYCLE   131
EVERY     29 CYCLES UNTIL CYCLE   160
EVERY     30 CYCLES UNTIL CYCLE  5C00
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0
EVERY      0 CYCLES UNTIL CYCLE     0

RMIN=   C.

SPHERICAL GECMETRY.
```

The problem is restarted from cycle 197
and C5 is changed from 10 to 20.

```
REGION     1. MATERIAL  1C00.
C1=  0.60C0E C1, C2=  0.5000E 00, C3=  0.1600E C1, C4=  C.2400E 02, C5=  C.2000E 02, E0= -C.1000E 01.
```

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	EL
1	0.6362E 00	C.2004E C3	0.4993E 02	0.1189E 03	0.3915E 01	C.1001E C4	C.1602F 09	0.1961E 09	0.7217E-03	0.1342E 01
2	0.8631E 00	C.2658E C3	0.4767F 02	0.1781E 03	0.2378E 01	0.9695E C3	0.1377E 09	0.1731E C9	0.7216E-03	C.1362E 01
3	C.1C78E C1	C.3262E 03	0.4702F 02	0.2814E 03	0.1467F C1	0.9960F 03	0.6283E 08	0.8273F 08	0.7217E-03	-0.3042E 03
4	0.1322E 01	C.3933E 03	0.6395E 02	0.4880E 03	0.1637E 01	0.1755E 04	C.3899E 08	0.3582E 08	0.7217E-03	-0.1320E 04
5	0.1474E C1	C.2991E 03	C.7300E 02	0.4118E 03	0.2556E 01	0.2159E C4	C.4481F 07	0.3100F 08	0.7217E-03	-0.1061E 04

```
REGION     2. MATERIAL  1C02.
C1=  C.60C0E C1, C2=  0.5000E 0C, C3=  0.1600E 01, C4=  0.2400E 02, C5=  C.2000F 02, E0= -0.1000F 01.
```

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	FL
6	0.1577E C1	C.2123E C3	0.7479E 02	0.3317E 03	0.8178E 01	0.7532E 04	C.4104F 07	0.4421E 07	0.7218E-03	0.3303E 04
7	0.1676E C1	C.1341E C3	0.7378E 02	0.3630E 03	0.7371E 01	0.7421E 04	0.3225F 07	0.4328E 07	0.7219E-03	0.8792E 04
8	C.18C0E C1	C.6433E C2	C.7181E 02	0.5209E 03	0.5019E 01	0.7339E C4	0.2769F 07	0.3483E 07	0.7219E-03	0.1302E 05
9	0.1943E C1	C.1813E C2	0.6984E 02	0.6930E 03	0.3678E 01	0.7198E C4	C.2660E 07	0.2987E 07	0.7219E-03	0.1487E 05
10	0.2C87E C1	0.2826E C1	0.6823E C2	0.8035E 03	0.3081E 01	0.7024E 04	0.2782E 07	0.2844F 07	0.7219E-03	0.1530E 05
11	C.2229E C1	C.2074E C1	0.6683E 02	0.8367E 03	0.2910E 01	0.6810E C4	0.2959E 07	0.2962E 07	0.7941E-03	0.1544E 05
12	0.2368E 01	C.2158E C1	0.6550E 02	0.8380E 03	0.2640E 01	0.6596E C4	0.3150E 07	0.3152F 07	0.8735E-03	0.1554E 05

J	R	U	TEM	VL	PR	EG	KP	KM	DMASS	EL
13	0.2504E 01	0.2286E 01	0.6419E 02	0.8387E 03	0.2774E 01	0.6397E 04	0.3360E 07	0.3361E 07	0.9608E-03	0.1561E 05
14	0.2638E 01	0.2462E 01	0.6288E 02	0.8394E 03	0.2709E 01	0.6208E 04	0.3594E 07	0.3596E 07	0.1057E-02	0.1564E 05
15	0.2771E 01	0.2699E 01	0.6154E 02	0.8403E 03	0.2643E 01	0.6026E 04	0.3860E 07	0.3864E 07	0.1163E-02	0.1562E 05
16	0.2905E 01	0.3016E 01	0.6015E 02	0.8415E 03	0.2574E 01	0.5849E 04	0.4171E 07	0.4176E 07	0.1279E-02	0.1556E 05
17	0.3039E 01	0.3444E 01	0.5869E 02	0.8430E 03	0.2502E 01	0.5673E 04	0.4343E 07	0.4550E 07	0.1407E-02	0.1544E 05
18	0.3175E 01	0.4031E 01	0.5713E 02	0.8448E 03	0.2426E 01	0.5495E 04	0.5005E 07	0.5012E 07	0.1547E-02	0.1524E 05
19	0.3312E 01	0.4855E 01	0.5542E 02	0.8467E 03	0.2343E 01	0.5313E 04	0.5604E 07	0.5610E 07	0.1702E-02	0.1495E 05
20	0.3450E 01	0.6030E 01	0.5349E 02	0.8481E 03	0.2252E 01	0.5121E 04	0.6461E 07	0.6436E 07	0.1872E-02	0.1457E 05
21	0.3591E 01	0.7675E 01	0.5122E 02	0.8434E 03	0.2163E 01	0.4909E 04	0.7894E 07	0.7739E 07	0.2060E-02	0.1406E 05
22	0.3729E 01	0.8961E 01	0.4832E 02	0.8197E 03	0.2092E 01	0.4655E 04	0.1056E 08	0.1037E 08	0.2266E-02	0.1345E 05
23	0.3867E 01	0.6612E 01	0.4392E 02	0.7386E 03	0.1941E 01	0.4310E 04	0.2432E 08	0.2475E 08	0.2492E-02	0.1288E 05
24	0.4012E 01	0.4868E 00	0.1246E 02	0.8188E 03	0.3734E 00	0.1439E 04	0.1474E 10	0.1493E 10	0.2741E-02	0.1463E 01
25	0.4162E 01	0.3403E-03	0.3694E-01	0.8329E 03	0.1272E-03	0.2639E 00	0.1387E 14	0.1385E 14	0.3016E-02	0.7687E-14
26	0.4316E 01	0.9846E-07	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3317E-02	0.
27	0.4473E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3649E-02	0.
28	0.4635E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4014E-02	0.
29	0.4800E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4415E-02	0.
30	0.4970E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4857E-02	0.
31	0.5144E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5342E-02	0.
32	0.5322E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5877E-02	0.
33	0.5506E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6464E-02	0.
34	0.5695E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7111E-02	0.
35	0.5889E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7822E-02	0.
36	0.6089E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8604E-02	0.
37	0.6295E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9464E-02	0.
38	0.6507E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1041E-01	0.
39	0.6725E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1145E-01	0.
40	0.6949E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1260E-01	0.
41	0.7181E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1386E-01	0.
42	0.7419E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1524E-01	0.
43	0.7665E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1677E-01	0.
44	0.7918E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1844E-01	0.
45	0.8179E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2029E-01	0.
46	0.8448E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2232E-01	0.
47	0.8725E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2455E-01	0.
48	0.9011E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2700E-01	0.
49	0.9306E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2970E-01	0.
50	0.9611E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3267E-01	0.
51	0.9925E 01	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3594E-01	0.
52	0.1025E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3954E-01	0.
53	0.1058E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4349E-01	0.
54	0.1093E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4784E-01	0.
55	0.1128E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5262E-01	0.
56	0.1165E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5788E-01	0.
57	0.1203E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6367E-01	0.
58	0.1242E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7004E-01	0.
59	0.1282E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7704E-01	0.
60	0.1324E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8475E-01	0.

J	R	H	TEM	VL	PK	EG	KP	KM	DMASS	EL
61	0.1367E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9322E-01	0.
62	0.1411E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1025E 00	0.
63	0.1457E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1128E 00	0.
64	0.1504E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1241E 00	0.
65	0.1553E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1365E 00	0.
66	0.1603E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1501E 00	0.
67	0.1655E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1651E 00	0.
68	0.1708E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1817E 00	0.
69	0.1764E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1998E 00	0.
70	0.1821E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2198E 00	0.
71	0.1879E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2418E 00	0.
72	0.1940E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2660E 00	0.
73	0.2003E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.2926E 00	0.
74	0.2068E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3218E 00	0.
75	0.2134E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3540E 00	0.
76	0.2203E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.3894E 00	0.
77	0.2275E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4284E 00	0.
78	0.2348E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.4712E 00	0.
79	0.2424E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5183E 00	0.
80	0.2502E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.5701E 00	0.
81	0.2583E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6272E 00	0.
82	0.2667E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.6899E 00	0.
83	0.2753E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.7589E 00	0.
84	0.2842E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.8347E 00	0.
85	0.2933E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.9182E 00	0.
86	0.3028E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1010E 01	0.
87	0.3126E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1111E 01	0.
88	0.3227E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1222E 01	0.
89	0.3331E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.4309E 14	0.4309E 14	0.1344E 01	0.
90	0.3439E 02	0.	0.2930E-01	0.8333E 03	0.1009E-03	0.2097E 00	0.	0.	0.1479E 01	0.

DT= 0.5580839E-04, DTP= 0.5580838E-04.

MASS ADD INFO.
JO= 4, JCS= 0, JCM= 80, DR= -0.3000000E-01.

PERCENTS.
X1= 0.2000E-05, X2= 0.8000E-05, X3= 0.4000E-05, X4= 0.2000E-05, X5= 0.1000E 00, X6= 0.2000E-03.

Z2= 0.2931000E-01, JHAT= 26, JL= 89, Z1= 0.3000000E-01, JSTAR= 25.

NF= 5000

NS= 197 TRAL= 7 10/7/65-HAR. TEST CASE 2-S.P.-IMP.

C1	C2	C3	C4	C5
0.6000E 01	0.5000E 00	0.1600E 01	0.2400E 02	0.2000E 02
0.6000E 01	0.5000E 00	0.1600E 01	0.2400E 02	0.2000E 02

JG	JCS	JCM	ORC
4	0	80	-0.3000E-01

Z1	Z2	JL	JHAT	JSTAR
0.3000E-01	0.2531E-01	89	26	25

X1	X2	X3	X4	X5	X6
0.2000E-05	0.8000E-05	0.4000E-05	0.2030E-05	0.1000E 00	0.2900E-03

RADIUS IS PRINTED IN FEET

PVELOC IS PRINTED IN FT/SEC

PRESUR IS PRINTED IN PSI

DENSTY IS PRINTED IN KG/M3

INTENG IS PRINTED IN CAL/GM

TEMP IS PRINTED IN KELVIN

DYNPRS IS PRINTED IN PSI

ARTVIS IS PRINTED IN PSI

LMNSTY IS PRINTED IN KT/SEC

ROSMFP IS PRINTED IN FEET

NETPWR IS PRINTED IN CAL/SC

RALCRT IS PRINTED IN CAL/SC

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
MATERIAL 1000												
1	6.574E 05	2.393E 05	4.993E 05	2.087E 00	8.407E 00	5.677E 05	6.118E 06	0.	4.031E 00	2.78E-03	5.37E 09	0.
2	6.719E 05	2.317E 05	4.767E 05	2.832E 00	5.616E 00	3.448E 05	2.212E 07	0.	4.090E 00	4.53E-03	3.63E 08	0.
3	1.070E 06	2.380E 05	4.702E 05	3.536E 00	3.553E 00	2.127E 05	2.256E 07	0.	-9.133E 02	8.71E-03	-1.13E 13	0.
4	1.290E 06	4.192E 05	6.395E 05	4.336E 00	2.049E 00	2.374E 05	1.923E 07	0.	-3.963E 03	4.66E-02	-1.78E 14	0.
5	9.813E 05	5.160E 05	7.300E 05	4.835E 00	2.428E 00	3.707E 05	2.110E 07	3.11E 05	-3.187E 03	5.53E-02	8.60E 13	0.
MATERIAL 1002												
6	6.964E 05	1.800E 06	7.479E 05	5.172E 00	3.015E 00	1.186E 06	1.429E 07	3.37E 06	9.918E 03	3.31E-01	1.28E 16	0.
7	4.401E 05	1.773E 06	7.376E 05	5.497E 00	2.755E 00	1.069E 06	5.991E 06	3.73E 06	2.640E 04	3.77E-01	1.91E 16	0.
8	2.110E 05	1.754E 06	7.181E 05	5.906E 00	1.920E 00	7.277E 05	1.371E 06	2.52E 06	3.910E 04	6.74E-01	2.10E 16	0.
9	5.949E 04	1.723E 06	6.984E 05	6.374E 00	1.443E 00	5.333E 05	1.778E 05	9.92E 05	4.464E 04	1.04E 00	1.23E 16	0.
10	9.272E 03	1.678E 06	6.823E 05	6.846E 00	1.237E 00	4.468E 05	9.847E 03	1.03E 05	4.594E 04	1.27E 00	3.51E 15	0.
11	6.805E 03	1.627E 06	6.683E 05	7.314E 00	1.195E 00	4.220E 05	5.201E 02	1.14E 02	4.637E 04	1.26E 00	1.15E 15	0.
12	7.079E 03	1.576E 06	6.550E 05	7.768E 00	1.193E 00	4.118E 05	3.873E 02	0.	4.667E 04	1.19E 00	7.78E 14	0.

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	FALORT
13	7.495E 03	1.528E 06	6.419E 05	8.214E 00	1.192E 00	4.023E 05	4.267E 02	0.	4.687E 04	1.12E 00	5.02E 14	0.
14	8.077E 03	1.483E 06	6.288E 05	8.654E 00	1.191E 00	3.928E 05	4.867E 02	0.	4.696E 04	1.05E 00	2.12E 14	0.
15	8.855E 03	1.440E 06	6.154E 05	9.092E 00	1.190E 00	3.832E 05	5.745E 02	0.	4.692E 04	9.78E-01	-9.04E 13	0.
16	9.856E 03	1.398E 06	6.015E 05	9.530E 00	1.188E 00	3.733E 05	7.036E 02	0.	4.672E 04	9.09E-01	-4.01E 14	0.
17	1.130E 04	1.356E 06	5.869E 05	9.971E 00	1.186E 00	3.629E 05	8.974E 02	0.	4.635E 04	8.40E-01	-7.15E 14	0.
18	1.322E 04	1.313E 06	5.713E 05	1.042E 01	1.184E 00	3.517E 05	1.199E 03	0.	4.576E 04	7.69E-01	-1.03E 15	0.
19	1.593E 04	1.270E 06	5.542E 05	1.086E 01	1.181E 00	3.397E 05	1.690E 03	0.	4.490E 04	6.95E-01	-1.32E 15	0.
20	1.978E 04	1.224E 06	5.349E 05	1.132E 01	1.179E 00	3.266E 05	2.532E 03	0.	4.374E 04	6.15E-01	-1.57E 15	0.
21	2.518E 04	1.173E 06	5.122E 05	1.178E 01	1.196E 00	3.136E 05	4.037E 03	0.	4.221E 04	5.22E-01	-1.73E 15	0.
22	2.940E 04	1.112E 06	4.832E 05	1.223E 01	1.220E 00	3.034E 05	6.120E 03	0.	4.040E 04	4.02E-01	-1.61E 15	0.
23	2.165E 04	1.030E 06	4.392E 05	1.269E 01	1.252E 00	2.814E 05	5.504E 03	1.81E 03	3.868E 04	2.69E-01	-1.02E 15	0.
24	1.557E 03	3.437E 05	1.246E 05	1.316E 01	1.221E 00	5.414E 04	1.116E 03	1.85E 04	4.393E 00	3.24E-03	-2.64E 14	0.
25	1.118E 00	5.306E 01	3.694E 02	1.366E 01	1.201E 00	1.845E 01	5.164E 00	1.35E 02	2.303E-14	5.35E-07	-4.76E 06	0.
26	3.230E-04	5.010E 01	2.930E 02	1.416E 01	1.200E 00	1.463E 01	2.520E-06	0.	0.	8.38E-08	-3.83E-09	0.
27	0.	5.010E 01	2.930E 02	1.468E 01	1.200E 00	1.463E 01	2.108E-13	0.	0.	8.38E-08	0.	0.
28	0.	5.010E 01	2.930E 02	1.521E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
29	0.	5.010E 01	2.930E 02	1.575E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
198	0.335085E-02	0.558084E-04	0.8652E 00	7	0.2095E-02	7	0.5625E 00	1	4	25	26	3
199	0.341364E-02	0.627844E-04	0.9886E 00	7	0.2901E-02	7	0.6060E 00	11	4	25	25	3
200	0.348420E-02	0.706325E-04	0.8956E 00	7	0.2542E-02	7	0.5372E 00	11	4	25	26	3

HISTORY EDIT AT CYCLE 200.

201	0.354700E-02	0.627844E-04	0.9117E 00	7	0.2796E-02	7	0.5361E 00	11	4	25	26	4
202	0.360984E-02	0.627844E-04	0.9333E 00	7	0.3084E-02	7	0.5357E 00	11	4	25	26	4
203	0.367263E-02	0.627844E-04	0.9596E 00	7	0.3413E-02	7	0.5359E 00	11	4	25	27	4
204	0.373541E-02	0.627844E-04	0.9908E 00	7	0.3791E-02	7	0.5367E 00	11	4	26	27	3
205	0.379820E-02	0.627844E-04	0.9125E 00	7	0.3339E-02	7	0.4736E 00	11	4	26	27	4
206	0.385401E-02	0.558084E-04	0.9434E 00	7	0.3712E-02	6	0.5000E 00	1	4	26	27	3
207	0.390981E-02	0.558084E-04	0.9767E 00	7	0.4144E-02	6	0.5000E 00	1	4	26	27	3
208	0.396562E-02	0.558084E-04	0.8990E 00	7	0.3665E-02	6	0.4444E 00	1	4	26	27	3
209	0.401523E-02	0.496074E-04	0.9266E 00	7	0.4059E-02	6	0.5000E 00	1	4	26	27	3
210	0.406484E-02	0.496074E-04	0.9549E 00	7	0.4502E-02	6	0.5000E 00	1	4	26	27	3
211	0.411445E-02	0.496074E-04	0.9832E 00	7	0.5002E-02	6	0.5000E 00	1	4	26	27	3
212	0.416405E-02	0.496074E-04	0.8989E 00	7	0.4397E-02	6	0.4444E 00	1	4	26	27	3
213	0.420815E-02	0.440955E-04	0.9198E 00	7	0.4839E-02	6	0.5000E 00	1	4	26	27	3
214	0.425224E-02	0.440955E-04	0.9410E 00	7	0.5330E-02	6	0.5000E 00	1	4	26	27	3
215	0.429634E-02	0.440955E-04	0.9616E 00	7	0.5875E-02	6	0.5000E 00	1	4	26	27	3
216	0.434043E-02	0.440955E-04	0.9813E 00	7	0.6480E-02	6	0.5000E 00	1	4	26	27	3
217	0.438453E-02	0.440955E-04	0.9999E 00	7	0.7150E-02	6	0.5000E 00	1	4	26	27	3
218	0.442863E-02	0.440955E-04	0.9042E 00	7	0.6234E-02	6	0.4444E 00	1	4	26	27	3
219	0.446782E-02	0.391960E-04	0.9153E 00	7	0.6805E-02	6	0.5000E 00	1	4	26	27	3
220	0.450702E-02	0.391960E-04	0.9265E 00	7	0.7427E-02	6	0.5000E 00	1	4	26	27	3

E	K	W	Y	W-Y+Y	JREG
0.189402E-01	0.365955E 00	0.387895E 00	0.301951E 00	0.689846E 00	5
0.463764E 00	0.142367E 00	0.606131E 00	0.262829E-04	0.304207E 00	90
0.482765E 00	0.511322E 00	0.994026E 00			

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALURT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	6.590E 05	1.613E 05	3.643E 05	2.885E 00	3.183E 00	1.133E 05	2.327E 06	0.	-7.440E 01	5.93E-03	-1.53E 11	-0.
2	8.710E 05	2.708E 05	4.936E 05	3.829E 00	2.198E 00	1.465E 05	8.663E 06	0.	-3.445E 03	2.02E-02	-6.79E 13	-0.
3	1.071E 06	5.180E 05	7.061E 05	4.833E 00	1.414E 00	2.050E 05	8.975E 06	0.	-5.998E 03	1.11E-01	-3.01E 14	-0.
4	9.949E 05	6.061E 05	7.509E 05	5.754E 00	9.851E-01	1.664E 05	7.077E 06	0.	-7.155E 03	2.35E-01	-2.95E 14	-0.
5	8.200E 05	5.400E 05	7.791E 05	5.916E 00	4.626E 00	7.969E 05	2.566E 07	2.78E 06	1.894E 03	2.62E-02	1.46E 15	-0.
MATERIAL 1002												
6	7.020E 05	1.758E 06	7.740E 05	6.017E 00	7.072E 00	2.853E 06	2.758E 07	2.34E 06	1.273E 04	7.51E-02	8.03E 15	-0.
7	5.784E 05	1.719E 06	7.619E 05	6.119E 00	6.753E 00	2.679E 06	1.864E 07	2.74E 06	2.533E 04	7.88E-02	9.58E 15	-0.
8	4.119E 05	1.727E 06	7.415E 05	6.288E 00	3.940E 00	1.528E 06	6.506E 06	3.02E 06	4.008E 04	1.99E-01	1.74E 16	-0.
9	2.336E 05	1.724E 06	7.157E 05	6.549E 00	2.367E 00	8.953E 05	1.660E 06	2.17E 06	5.147E 04	4.64E-01	2.02E 16	-0.
10	9.103E 04	1.706E 06	7.003E 05	6.895E 00	1.632E 00	6.034E 05	2.897E 05	1.04E 06	5.673E 04	8.40E-01	1.29E 16	-0.
11	1.821E 04	1.678E 06	6.837E 05	7.325E 00	1.287E 00	4.655E 05	2.586E 04	2.28E 05	5.756E 04	1.20E 00	2.17E 15	-0.
12	8.818E 03	1.630E 06	6.690E 05	7.778E 00	1.196E 00	4.226E 05	1.471E 03	3.03E 03	5.676E 04	1.27E 00	-2.24E 15	-0.
13	9.145E 03	1.577E 06	6.551E 05	8.224E 00	1.188E 00	4.101E 05	6.456E 02	0.	5.574E 04	1.20E 00	-2.76E 15	-0.
14	9.745E 03	1.527E 06	6.414E 05	8.665E 00	1.186E 00	4.000E 05	7.128E 02	0.	5.465E 04	1.12E 00	-2.76E 15	-0.
15	1.057E 04	1.481E 06	6.277E 05	9.104E 00	1.184E 00	3.899E 05	8.231E 02	0.	5.351E 04	1.05E 00	-2.74E 15	-0.
16	1.168E 04	1.436E 06	6.139E 05	9.543E 00	1.182E 00	3.796E 05	9.855E 02	0.	5.231E 04	9.82E-01	-2.68E 15	-0.
17	1.319E 04	1.393E 06	5.998E 05	9.986E 00	1.178E 00	3.690E 05	1.227E 03	0.	5.105E 04	9.13E-01	-2.60E 15	-0.
18	1.524E 04	1.351E 06	5.850E 05	1.043E 01	1.174E 00	3.578E 05	1.597E 03	0.	4.973E 04	8.45E-01	-2.50E 15	-0.
19	1.807E 04	1.309E 06	5.694E 05	1.089E 01	1.168E 00	3.459E 05	2.183E 03	0.	4.833E 04	7.77E-01	-2.39E 15	-0.
20	2.181E 04	1.267E 06	5.526E 05	1.135E 01	1.162E 00	3.334E 05	3.114E 03	0.	4.687E 04	7.06E-01	-2.25E 15	-0.
21	2.644E 04	1.222E [illegible]5	5.339E 05	1.181E 01	1.164E 00	3.219E 05	4.564E 03	0.	4.533E 04	6.24E-01	-2.06E 15	-0.
22	3.158E 04	1.17[illegible] 5	5.118E 05	1.227E 01	1.197E 00	3.165E 05	6.786E 03	0.	4.375E 04	5.12E-01	-1.76E 15	-0.
23	3.311E 04	1.112E 06	4.835E 05	1.272E 01	1.247E 00	3.101E 05	8.786E 03	0.	4.227E 04	3.88E-01	-1.27E 15	-0.
24	3.035E 04	1.031E 06	4.399E 05	1.318E 01	1.265E 00	2.847E 05	8.576E 03	2.15E 01	4.093E 04	2.67E-01	-7.78E 14	2.01E 05
25	5.560E 03	6.274E 05	2.105E 05	1.366E 01	1.242E 00	1.212E 05	2.697E 03	2.81E 04	1.419E 02	1.63E-02	-1.39E 15	1.16E 13
26	2.207E 01	3.002E 02	1.559E 03	1.416E 01	1.203E 00	7.805E 01	6.314E 01	1.46E 03	6.620E-07	5.40E-02	-1.57E 13	4.99E-03
27	2.439E-03	5.010E 01	2.930E 02	1.468E 01	1.200E 00	1.463E 01	9.844E-04	2.72E-01	0.	8.39E-08	-1.07E-01	0.
28	0.	5.010E 01	2.930E 02	1.521E 01	1.200E 00	1.463E 01	1.202E-11	0.	0.	8.38E-08	0.	0.
29	0.	5.010E 01	2.930E 02	1.575E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
30	0.	5.010E 01	2.930E 02	1.630E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
221	0.454021E-02	0.391960E-04	0.9353E 00	7	0.8102E-02	6	0.5000E 00	1	4	26	27	4
222	0.458541E-02	0.391960E-04	0.9444E 00	7	0.8834E-02	6	0.5000E 00	1	4	26	27	4
223	0.462461E-02	0.391960E-04	0.9505E 00	7	0.9624E-02	6	0.5000E 00	1	4	26	28	4
224	0.466380E-02	0.391960E-04	0.9544E 00	7	0.1047E-01	6	0.5000E 00	1	4	26	28	4
225	0.470300E-02	0.391960E-04	0.9558E 00	7	0.1138E-01	6	0.5000E 00	1	4	26	28	3
226	0.474219E-02	0.391960E-04	0.9543E 00	7	0.1239E-01	7	0.5000E 00	1	4	27	28	4
227	0.478139E-02	0.391960E-04	0.9496E 00	7	0.1358E-01	7	0.5000E 00	1	4	27	28	4
228	0.482059E-02	0.391960E-04	0.9414E 00	7	0.1488E-01	7	0.5000E 00	1	4	27	28	3
229	0.485978E-02	0.391960E-04	0.9429E 00	8	0.1628E-01	7	0.5000E 00	1	4	27	28	3
230	0.489858E-02	0.391960E-04	0.9608E 00	8	0.1778E-01	7	0.5000E 00	1	4	27	28	3
231	0.493817E-02	0.391960E-04	0.9782E 00	8	0.1939E-01	7	0.5000E 00	1	4	27	28	3
232	0.497737E-02	0.391960E-04	0.9950E 00	8	0.2110E-01	7	0.5000E 00	1	4	27	28	3
233	0.501657E-02	0.391960E-04	0.8787E 00	8	0.1809E-01	7	0.4444E 00	1	4	27	28	3
234	0.505141E-02	0.348409E-04	0.9391E 00	8	0.1940E-01	7	0.5000E 00	1	4	27	28	3
235	0.508625E-02	0.348409E-04	0.9201E 00	8	0.2075E-01	7	0.5000E 00	1	4	27	28	3
236	0.512109E-02	0.348409E-04	0.9301E 00	8	0.2213E-01	7	0.5000E 00	1	4	27	28	3
237	0.515593E-02	0.348409E-04	0.9389E 00	8	0.2351E-01	7	0.5000E 00	1	4	27	28	3
238	0.519077E-02	0.348409E-04	0.9454E 00	8	0.2488E-01	7	0.5000E 00	1	4	27	28	3
239	0.522561E-02	0.348409E-04	0.9522E 00	8	0.2621E-01	7	0.5000E 00	1	4	27	28	3

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
240	0.526045E-02	0.348409E-04	0.9560E 00	8	0.2750E-01	7	0.5000E 00	1	4	27	28	3
241	0.529529E-02	0.348409E-04	0.9578E 00	8	0.2872E-01	7	0.5000E 00	1	4	27	28	3
242	0.533013E-02	0.348409E-04	0.9571E 00	8	0.2983E-01	7	0.5000E 00	1	4	27	28	3
243	0.536497E-02	0.348409E-04	0.9534E 00	8	0.3083E-01	7	0.5000E 00	1	4	27	28	3
244	0.539981E-02	0.348409E-04	0.9466E 00	8	0.3170E-01	7	0.5000E 00	1	4	27	28	3
245	0.543465E-02	0.348409E-04	0.9352E 00	8	0.3242E-01	7	0.5000E 00	1	4	27	28	3
246	0.546950E-02	0.348409E-04	0.9217E 00	8	0.3298E-01	7	0.5000E 00	1	4	27	28	3
247	0.550434E-02	0.348409E-04	0.9333E 00	9	0.3335E-01	7	0.5000E 00	1	4	27	28	3
248	0.553918E-02	0.348409E-04	0.9523E 00	9	0.3355E-01	7	0.5000E 00	1	4	27	28	3
249	0.557402E-02	0.348409E-04	0.9710E 00	9	0.3356E-01	7	0.5000E 00	1	4	27	28	4
250	0.560886E-02	0.348409E-04	0.9892E 00	9	0.3339E-01	7	0.5000E 00	1	4	27	29	3

F	K	W	Y	W-Y+Y	JREG
0.220807E-01	0.292707E 00	0.314787E 00	0.303212E 00	0.617999E 00	5
0.520038E 00	0.159254E 00	0.679292E 00	0.355018E-04	0.376115E 00	90
0.542118E 00	0.451561E 00	0.994079E 00			

HISTORY EDIT AT CYCLE 250.

J	PVELOC	INTEN	TEMP	RADIUS	DENSTY	PRESUR	DYNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	6.561E 05	2.514E 05	4.627E 05	3.610E 00	1.625E 00	9.499E 04	1.178E 06	0.	-2.675E 03	2.71E-02	-2.01E 13	-0.
2	8.722E 05	5.171E 05	6.947E 05	4.649E 00	1.142E 00	1.616E 05	4.492E 06	0.	-5.138E 03	1.46E-01	-2.90E 14	-0.
3	1.041E 06	6.058E 05	7.329E 05	6.009E 00	7.426E-01	1.216E 05	4.579E 06	0.	-7.866E 03	3.31E-01	-7.78E 14	-0.
4	6.687E 05	6.369E 05	7.516E 05	6.652E 00	9.871E-01	1.671E 05	4.861E 06	1.54E 06	-2.693E 02	2.35E-01	2.77E 15	-0.
5	6.081E 05	4.653E 05	7.525E 05	6.699E 00	1.215E 01	1.930E 06	3.335E 07	1.27E 06	4.204E 03	5.47E-03	5.20E 14	-0.
MATERIAL 1002												
6	6.123E 05	1.571E 06	7.385E 05	6.750E 00	1.105E 01	4.221E 06	2.776E 07	0.	2.972E 03	2.95E-02	-7.13E 14	-0.
7	6.151E 05	1.534E 06	7.348E 05	6.791E 00	1.366E 01	5.182E 06	3.470E 07	0.	2.168E 03	1.97E-02	-3.90E 14	-0.
8	5.629E 05	1.540E 06	7.320E 05	6.837E 00	1.210E 01	4.574E 06	2.826E 07	9.39E 05	1.016E 04	2.45E-02	4.32E 15	-0.
9	4.439E 05	1.595E 06	7.223E 05	6.926E 00	6.041E 00	2.265E 06	1.031E 07	2.67E 06	2.605E 04	8.50E-02	1.52E 16	-0.
10	2.925E 05	1.555E 06	7.070E 05	7.094E 00	3.075E 00	1.137E 06	2.735E 06	2.51E 06	4.229E 04	2.75E-01	2.65E 16	-0.
11	1.245E 05	1.658E 06	6.923E 05	7.393E 00	1.792E 00	6.525E 05	5.010E 05	1.44E 06	5.230E 04	6.87E-01	2.30E 16	-0.
12	2.946E 04	1.649E 06	6.781E 05	7.794E 00	1.333E 00	4.774E 05	5.325E 04	4.07E 05	5.537E 04	1.10E 00	8.39E 15	-0.
13	1.103E 04	1.615E 06	6.653E 05	8.235E 00	1.197E 00	4.205E 05	3.306E 03	1.29E 04	5.570E 04	1.24E 00	9.19E 14	-0.
14	1.130E 04	1.573E 06	6.530E 05	8.676E 00	1.182E 00	4.065E 05	9.921E 02	0.	5.560E 04	1.20E 00	-2.69E 14	-0.
15	1.216E 04	1.528E 06	6.408E 05	9.116E 00	1.179E 00	3.970E 05	1.093E 03	0.	5.542E 04	1.13E 00	-4.47E 14	-0.
16	1.334E 04	1.484E 06	6.284E 05	9.557E 00	1.175E 00	3.873E 05	1.287E 03	0.	5.517E 04	1.07E 00	-6.12E 14	-0.
17	1.492E 04	1.443E 06	6.157E 05	1.000E 01	1.170E 00	3.772E 05	1.574E 03	0.	5.483E 04	1.01E 00	-7.82E 14	-0.
18	1.708E 04	1.403E 06	6.026E 05	1.045E 01	1.164E 00	3.664E 05	2.007E 03	0.	5.437E 04	9.47E-01	-9.54E 14	-0.
19	1.998E 04	1.363E 06	5.889E 05	1.091E 01	1.156E 00	3.549E 05	2.673E 03	0.	5.389E 04	8.87E-01	-1.12E 15	-0.
20	2.349E 04	1.323E 06	5.742E 05	1.137E 01	1.149E 00	3.430E 05	3.651E 03	0.	5.308E 04	8.24E-01	-1.26E 15	-0.
21	2.709E 04	1.282E 06	5.583E 05	1.184E 01	1.148E 00	3.328E 05	4.944E 03	0.	5.224E 04	7.48E-01	-1.33E 15	-0.
22	3.158E 04	1.236E 06	5.402E 05	1.231E 01	1.177E 00	3.294E 05	6.914E 03	0.	5.123E 04	6.39E-01	-1.39E 15	-0.
23	3.564E 04	1.184E 06	5.185E 05	1.276E 01	1.231E 00	3.298E 05	9.478E 03	0.	5.011E 04	5.12E-01	-1.26E 15	-0.
24	3.618E 04	1.125E 06	4.922E 05	1.322E 01	1.258E 00	3.175E 05	1.093E 04	0.	4.894E 04	4.02E-01	-1.04E 15	-0.
25	3.328E 04	1.042E 06	4.468E 05	1.368E 01	1.277E 00	2.922E 05	1.037E 04	2.14E 01	4.744E 04	2.78E-01	-9.02E 14	2.20E 05
26	7.855E 03	7.533E 05	2.737E 05	1.415E 01	1.252E 00	1.680E 05	3.568E 03	2.95E 04	1.103E 03	4.35E-02	-4.18E 15	1.69E 13
27	4.953E 01	1.475E 03	4.536E 03	1.458E 01	1.205E 00	2.478E 02	1.268E 02	2.86E 03	1.463E-01	6.37E 01	-1.37E 17	4.25E 05
28	7.781E-03	5.016E 01	2.933E 02	1.521E 01	1.200E 00	1.464E 01	4.958E-03	6.66E-01	0.	8.46E-08	-2.34E 04	0.
29	0.	5.010E 01	2.930E 02	1.575E 01	1.200E 00	1.463E 01	1.223E-10	0.	0.	8.38E-08	0.	0.
30	0.	5.010E 01	2.930E 02	1.630E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
31	0.	5.010E 01	2.930E 02	1.688E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
32	0.	5.010E 01	2.930E 02	1.746E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

N	TIME	DT	LAMBDA	JLAM	OMEGA	JOMEGA	GAMMA	JGAM	JO	JSTAR	JHAT	IC
251	0.564370E-02	0.348409E-04	0.8949E 00	9	0.2613E-01	7	0.4444E 00	1	4	27	29	4
252	0.567467E-02	0.309697E-04	0.9055E 00	9	0.2582E-01	7	0.5000E 00	1	4	27	29	4
253	0.570564E-02	0.309697E-04	0.9183E 00	9	0.2565E-01	8	0.5000E 00	1	4	28	29	3
254	0.573661E-02	0.309697E-04	0.9239E 00	9	0.2704E-01	8	0.5000E 00	1	4	28	29	3
255	0.576758E-02	0.309697E-04	0.9382E 00	9	0.2837E-01	8	0.5000E 00	1	4	28	29	4
256	0.579855E-02	0.309697E-04	0.9458E 00	9	0.2960E-01	8	0.5000E 00	1	4	28	29	3
257	0.582952E-02	0.309697E-04	0.9514E 00	9	0.3070E-01	8	0.5000E 00	1	4	28	29	3
258	0.586049E-02	0.309697E-04	0.9549E 00	9	0.3163E-01	8	0.5000E 00	1	4	28	29	3
259	0.589146E-02	0.309697E-04	0.9560E 00	9	0.3237E-01	8	0.5000E 00	1	4	28	29	3

E	K	W	Y	W-Y+Y	JREG
0.239304E-01	0.272453E 00	0.296383E 00	0.304839E 00	0.601222E 00	5
0.534055E 00	0.163718E 00	0.697773E 00	0.378673E-04	0.392972E 00	90
0.557958E 00	0.436171E 00	0.994156E 00			

HISTORY EDIT AT CYCLE 259.

J	PVELOC	INTENG	TEMP	RADIUS	DENSTY	PRESUR	DVNPRS	ARTVIS	LMNSTY	ROSMFP	NETPWR	RALORT
0	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.	-0.
MATERIAL 1000												
1	6.595E 05	5.410E 05	5.519E 05	3.795E 00	1.398E 00	1.193E 05	1.012E 06	0.	-4.237E 03	5.36E-02	-5.98E 13	-0.
2	8.729E 05	5.676E 05	7.241E 05	5.095E 00	9.851E-01	1.538E 05	3.875E 06	0.	-7.133E 03	2.08E-01	-4.64E 14	-0.
3	9.800E 05	6.570E 05	7.534E 05	6.294E 00	6.531E-01	1.161E 05	3.776E 06	0.	-9.752E 03	4.46E-01	-9.74E 14	-0.
4	6.213E 05	6.278E 05	7.723E 05	6.833E 00	1.096E 00	1.953E 05	4.731E 06	2.23E 06	3.833E 03	2.20E-01	5.55E 15	-0.
5	5.804E 05	4.573E 05	7.601E 05	6.866E 00	1.651E 01	2.672E 06	4.015E 07	8.06E 05	7.256E 03	3.57E-03	3.71E 14	-0.
MATERIAL 1032												
6	5.308E 05	1.570E 06	7.357E 05	6.918E 00	1.033E 01	3.930E 06	2.345E 07	0.	6.097E 03	3.32E-02	-7.40E 14	-0.
7	5.930E 05	1.531E 06	7.293E 05	6.962E 00	1.213E 01	4.569E 06	2.814E 07	0.	3.305E 03	2.42E-02	-1.55E 15	-0.
8	5.787E 05	1.501E 06	7.252E 05	6.998E 00	1.434E 01	5.366E 06	3.317E 07	3.97E 04	4.940E 03	1.75E-02	7.84E 14	-0.
9	4.915E 05	1.543E 06	7.197E 05	7.059E 00	8.552E 00	3.185E 06	1.649E 07	2.05E 06	1.797E 04	4.45E-02	9.52E 15	-0.
10	3.455E 05	1.598E 06	7.074E 05	7.184E 00	4.811E 00	1.477E 06	4.732E 06	2.74E 06	3.555E 04	1.70E-01	2.38E 16	-0.
11	1.760E 05	1.537E 06	6.928E 05	7.436E 00	2.086E 00	7.580E 05	9.555E 05	1.91E 06	4.915E 04	5.23E-01	2.83E 16	-0.
12	5.253E 04	1.539E 06	6.786E 05	7.805E 00	1.436E 00	5.138E 05	1.264E 05	7.31E 05	5.446E 04	9.62E-01	1.38E 16	-0.
13	1.294E 04	1.513E 06	6.656E 05	8.238E 00	1.218E 00	4.279E 05	8.791E 03	6.45E 04	5.523E 04	1.21E 00	2.14E 15	-0.
14	1.165E 04	1.572E 06	6.534E 05	8.680E 00	1.181E 00	4.065E 05	1.206E 03	0.	5.513E 04	1.20E 00	-2.57E 14	-0.
15	1.256E 04	1.528E 06	6.414E 05	9.120E 00	1.177E 00	3.969E 05	1.165E 03	0.	5.496E 04	1.14E 00	-4.33E 14	-0.
16	1.375E 04	1.487E 06	6.292E 05	9.561E 00	1.173E 00	3.872E 05	1.367E 03	0.	5.475E 04	1.08E 00	-5.20E 14	-0.
17	1.536E 04	1.447E 06	6.168E 05	1.001E 01	1.168E 00	3.772E 05	1.666E 03	0.	5.447E 04	1.02E 00	-6.32E 14	-0.
18	1.754E 04	1.407E 06	6.039E 05	1.046E 01	1.161E 00	3.665E 05	2.116E 03	0.	5.411E 04	9.58E-01	-7.79E 14	-0.
19	2.045E 04	1.368E 06	5.905E 05	1.091E 01	1.152E 00	3.550E 05	2.602E 03	0.	5.362E 04	8.90E-01	-9.66E 14	-0.
20	2.388E 04	1.329E 06	5.765E 05	1.138E 01	1.144E 00	3.432E 05	3.787E 03	0.	5.296E 04	8.38E-01	-1.19E 15	-0.
21	2.722E 04	1.289E 06	5.608E 05	1.185E 01	1.144E 00	3.334E 05	5.031E 03	0.	5.207E 04	7.64E-01	-1.44E 15	-0.
22	3.155E 04	1.244E 06	5.436E 05	1.232E 01	1.172E 00	3.302E 05	6.909E 03	0.	5.077E 04	6.58E-01	-1.83E 15	-0.
23	3.606E 04	1.195E 06	5.232E 05	1.277E 01	1.226E 00	3.316E 05	9.551E 03	0.	4.882E 04	5.32E-01	-2.27E 15	-0.
24	3.701E 04	1.140E 06	4.979E 05	1.323E 01	1.255E 00	3.221E 05	1.129E 04	0.	4.571E 04	4.27E-01	-2.92E 15	-0.
25	3.516E 04	1.073E 06	4.637E 05	1.369E 01	1.277E 00	3.038E 05	1.120E 04	0.	3.980E 04	3.19E-01	-4.10E 15	-0.
26	1.594E 04	9.793E 05	4.100E 05	1.417E 01	1.267E 00	2.649E 05	5.571E 03	1.59E 04	2.625E 04	2.03E-01	-5.78E 15	2.12E 05
27	3.357E 02	7.015E 04	4.714E 04	1.468E 01	1.213E 00	1.068E 04	5.407E 02	1.13E 04	1.497E-01	2.78E-03	-1.43E 14	1.40E 12
28	1.038E-01	5.165E 01	3.025E 02	1.521E 01	1.200E 00	1.509E 01	2.279E-01	9.34E 00	8.516E-16	1.08E-07	-3.05E 04	1.03E-11
29	3.031E-04	5.016E 01	2.930E 02	1.575E 01	1.200E 00	1.463E 01	2.183E-08	0.	0.	8.38E-08	-1.32E-10	0.
30	0.	5.016E 01	2.930E 02	1.630E 01	1.200E 00	1.463E 01	1.857E-13	0.	0.	8.38E-08	0.	0.
31	0.	5.016E 01	2.930E 02	1.698E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.
32	0.	5.016E 01	2.930E 02	1.746E 01	1.200E 00	1.463E 01	0.	0.	0.	8.38E-08	0.	0.

V. DESCRIPTION OF "GENERATE" PROGRAM

INTRODUCTORY REMARKS

The Generator section of HAROLD reads data, with sufficient information to define a problem, from cards. It then generates all the constants and zone variables for the problem defined and writes them on the history tape, FORTRAN logical tape 12, as cycle 0.

The Generator is also used to change data when restarting a problem from a given cycle on the history tape. Any constants may be changed, but the zoning and zone variables may not be changed.

DATA DESCRIPTION

The Generator section of HAROLD has the following data cards. Those which are required are so indicated by an asterisk. The cards should be in the given order if present.

*START
*HISTORY
*PRINT OUT
*ENERGY EDIT
*TIME STEP
UNITS (RAND version only)
GEOMETRY
RMIN
EOS
*REGION
ZONE
(any other REGION and ZONE cards required)
ZSOURCE
RSOURCE
BOUNDARY
COMBINATION
ZTEMPERATURE
*PERCENTS
*ENDATA

Any number of 72 column BCD cards may be included before the START card. They will be printed at the beginning of the generate print-out for documentation purposes. Note that a $ may not occur in column 1.

The FORTRAN version requires that all documentation cards be preceded by a card with the number of documentation cards to follow in (I6) FORMAT, i.e., a right adjusted integer in cols. 1-6.

START Card

NS is the cycle number of the first cycle (0 for generating new problems, non-zero for restarting) and NF is the number of cycles desired. These parameters may occur in either order. IHYD is 0 for problems with radiation and non-zero for those with hydrodynamics only.

HISTORY EDIT Card

This card controls the frequency of history edits by cycle number or by time. History edits will be taken every ND cycles until cycle NC is reached, then the next ND-NC pair will be used; or history edits will be taken every DT msecs. until time equals CT, then the next DT-CT pair will be used. A maximum of six pairs may be specified. These parameters must be sequential, i.e.,

ND=	NC=	ND=	NC=	etc., or
DT=	CT=	DT=	CT=	etc.

The two types of pairs may not be intermixed.

PRINT OUT Card

This card controls the frequency of print outs. The parameters are identical to those of the HISTORY EDIT card.

ENERGY EDIT Card

This card controls the frequency of energy edits. The parameters are identical to those of the HISTORY EDIT card.

TIME STEP Card

The first DT is Δt^0 in msecs and the second is $\Delta t^{\frac{1}{2}}$ in msecs. Usually Δt^0 is equal to $\frac{1}{2}\Delta t^{\frac{1}{2}}$. $(\Delta t^n = \frac{1}{2}(\Delta t^{n-\frac{1}{2}} + \Delta t^{n+\frac{1}{2}}))$.

UNITS Card

The data on all input cards following the UNITS card may be specified in either MMEGMS (meters, megagrams and milliseconds) or in CGS units. If no UNITS card is present, MMEGMS (the units in which the calculation is done) is assumed. (See column two of the output data description form, p. 253, Sec. VI, for the details of MMEGMS units.) (Not applicable to all-FORTRAN HAROLD.)

GEOMETRY Cards

Either PLANE, SPHERICAL or CYLINDRICAL geometry may be specified. If no GEOMETRY card is present, plane geometry is assumed.

RMIN Card

R_0^0 may be specified. If it is not, $R_0^0 = 0$ is assumed.

EOS Card

This card is required only if tabular equations of state are used. It establishes the correspondence between the material numbers of regions using tabular equations of state (i.e., 0, 1, 2, 3, 4 or 5) and the equations of state to be used in those regions. The idno's are the identification numbers of those equations of state on the equation of state tape prepared by TABCOE. For example, if a problem were to use the tabular equations of state for aluminum and air, and these equations of state were identified on the equation of state tape prepared by TABCOE as 513 and 700 respectively, one might assign the material no.1 to aluminum and no.4 to air. Then the EOS card would be:

cols. 1	13	28	43
EOS	1= 513	4= 700	

REGION and ZONE Cards

REGION cards are used to specify the material of a region, all constants of a region and those zone variables which are consistent throughout the region. ZONE cards are used to specify only those variables which are not consistent throughout a region.

A. Material Specification.

m is the material number of the region. If the material is specified by an analytic equation of state one of the

material numbers 1000, 1001, ..., 1005 must be used. If it is tabular one of the material numbers 0, 1, ..., 5 must be used. If the equation of state is analytic and of the form P(E,V), T(E,V) rather than P(T,V), and E(T,V), the material number 2000, 2001, ..., 2005 must be used. The material numbers 2000, ..., 2005 are only permitted for problems with hydrodynamics only.

B. Number of zones specified by a ZONE card.

n is the number of zones specified by the ZONE card.

C. Specification of radii.

The R_j $_{j=1,jmax}$ may be specified on REGION cards by inputting R_{IR}, the outer radius of region number IR, with either J_{IR}, the corresponding j, or ΔR_{IR}, the uniform zone width. Specifying J_{IR} and ΔR_{IR} is also sufficient. The labels for these are R=, J= and DR=. The radii may also be specified on the ZONE cards by including either R_J, the outer radius of zone number j, or ΔR_j, the width of zone j, which will be added to R_{j-1} to yield R_j. The labels for the ZONE card are R= and DR=. If R_j is specified on a ZONE card, n must be 1.

D. Specification of V,T,P,E and K.

It is necessary to establish the values of T and V, the independent variables, in order to determine P, E and K. Any of these variables which are consistent throughout a region may be specified on the REGION card. Those which are not must be specified on ZONE cards. T may be specified through the use of the label T=. V may be input directly with the label V=. It is also possible to input Δm which determines V through the equation:

$$V_{j-\frac{1}{2}} = \frac{R_j^\delta - R_{j-1}^\delta}{\delta \, \Delta m_{j-\frac{1}{2}}} \qquad (76)$$

(see also (12))

where δ is 1, 2 or 3 for plane, cylindrical or spherical geometry respectively. The label for this is M=. Also ρ may be input with the label RH=, and V is determined by

$$V = 1/\rho.$$

Either of these independent variables may be omitted if one of the three dependent variables P, E or K is specified. If, for example, P and T are input, the equation of state P=P(T,V) may be solved for V. Any other pair consisting of a dependent and an independent variable is, of course, equally permissable. If the equation of state is analytic, neither independent variable need be specified, for if any two dependent variables are input, T and V are determined. For example, if P and E are input the equations of state

$$P=P(T,V)$$

and

$$E=E(T,V) \tag{77}$$

may be solved simultaneously for T and V. If the equation of state is tabular, inputting of two dependent variables is not permitted. If, for hydrodynamics-only problems, equations of state of the form P(E,V), T(E,V) are used, the above discussion holds if one reads T for E and E for T.

E. Specification of initial velocity.

The initial velocity of all zones in a region or those zones being defined by a ZONE card may be specified through the use of the label U= on the REGION or ZONE card respectively. If U is not specified, U=0 is assumed.

F. Other labels on REGION cards.

C1 and C2 are used in the artificial viscosity equation in the subroutine HYD:

$$Q^{n+\frac{1}{2}}_{j-\frac{1}{2}} = \frac{C1_{IR}\Delta m^2_{j-\frac{1}{2}}\,(V^{n+1}_{j-\frac{1}{2}} - V^n_{j-\frac{1}{2}})^2}{(V^{n+1}_{j-\frac{1}{2}} + V^n_{j-\frac{1}{2}})(\Delta t^{n+\frac{1}{2}})^2\left(\frac{R^{n+1}_j + R^{n+1}_{j-1}}{2}\right)^{2(\delta-1)}}$$

$$+ \frac{C2_{IR}\Delta m_{j-\frac{1}{2}}\left|V^{n+1}_{j-\frac{1}{2}} - V^n_{j-\frac{1}{2}}\right|}{(V^{n+1}_{j-\frac{1}{2}} + V^n_{j-\frac{1}{2}})\Delta t^{n+\frac{1}{2}}\left(\frac{R^{n+1}_j + R^{n+1}_{j-1}}{2}\right)^{(\delta-1)}} . \tag{78}$$

(also(13))

C3 is the Courant Stability constant in the equation:

$$X_{20} = \frac{(R_j^{n+1})^{2(\delta-1)} P_{j-\frac{1}{2}}^{n+1} \, C3_{IR}}{V_{j-\frac{1}{2}}^{n+1} \, (\Delta m_{j-\frac{1}{2}})^2} \, . \tag{79}$$

C4 is the artificial viscosity stability constant in the equation:

$$X_{30} = \frac{(V_{j-\frac{1}{2}}^{n} - V_{j-\frac{1}{2}}^{n+1}) \, C4_{IR}}{V_{j-\frac{1}{2}}^{n+1}} \, . \tag{80}$$

C5 is the radiation stability constant in the equation:

$$X_{10} = \frac{C5_{IR} \Delta m_{j-\frac{1}{2}} (K\Delta m)_j^{n+1} \dfrac{\partial E_{j-\frac{1}{2}}^{n+1}}{\partial T_{j-\frac{1}{2}}^{n+1}}}{8(R_j^{n+1})^{2(\delta-1)} (T_j^{n+1})^3} \, . \tag{81}$$

C3, C4 and C5 are used in the subroutines TSR, TSREXP and TSRIMP.

C1 is typically 6.

C2 ranges typically between 0 and ½.

C3 is typically 1.6 but may have to be increased for non-gaseous substances.

C4 is typically 16 but may be increased to reduce the time step.

C5 is 1 for explicit radiation problems and equal to or greater than 1 for implicit radiation.

E0 is the initial energy in the zones of a region. It is also used in the calculation for obtaining a value SUM2(IR) in GENRAT for the energy edit routine in ECHECK and it is used in CZR when combining of zones requires a new value for SUM2(IR). It may be equal to 0. If not input, E0 is assumed to be equal to 0. E0 may also be input as any negative number. This results in E0 being established as equal to the energy of the right-most zone in the region. The units of E0 are jerks/megagram (10^{10} ergs/gm).

RSOURCE and ZSOURCE Cards

These cards specify an energy rate sink or source in a region (RSOURCE) or zone (ZSOURCE). The sink or source is a step function with a maximum of six steps. The energy specified by each E=, TM= pair is inserted into the region or zone until time = TM. Then the next pair is used. The j's and r's are the zone and region numbers into which the energy is to be inserted. See subroutines RGSRFN and ZNSRFN (p. 282) for sources or sinks which are not step functions. The E is in MMEGMS (jks/meg/ms), viz, 10^{10} ergs/gm/msec. In the RAND version only, one can also input sources in CGS units (erg/gm/sec). Sources are negative; sinks, positive.

BOUNDARY Cards

Boundary conditions for U,P,E,T, and K may be specified at either $R_{-\frac{1}{2}}$ or $R_{jmax+\frac{1}{2}}$. These are introduced as step functions with a maximum of six steps. The first value specified on the boundary card is used until time equals the first TM, at which time the second pair is used. If no TM is specified on the boundary card, the value of U,P,E,T or K specified will be used throughout the problem. MIN corresponds to a boundary condition at $j=-\frac{1}{2}$ and MAX to a boundary condition at $j=jmax+\frac{1}{2}$. If $R_0^0 = 0$, $U_0^n = 0$ is assumed for all n, and only a $T_{-\frac{1}{2}}$ boundary condition is permitted at $j=-\frac{1}{2}$.

COMBINATION Cards

Zones may be combined and new zones added at the right hand boundary. This maintains a constant number of zones, but permits the introduction of additional mass into the problem during execution. Zones are combined between j=jos and j=jom. The labels JS= and JM= correspond to those two parameters. The first two zones to be combined will be the zones j=jo+1 and j=jo+2. If DR is positive, it is the ΔR of the zones to be added. If it is negative, its absolute value is the percentage of R_j which is to be used as the ΔR of the zone to be added. Combination of zones begins when j reaches $j\ell$ which is input on the ZTEMPERATURE card. Thus, as the shock front moves to the right, zones will be added in front of it, and zones behind the shock front will be combined.

Another form of combination of zones is permitted. In this case we have a pressure and density specified at the right hand boundary of the problem. These are specified through the subroutines PBOUND and RBOUND (see p. 331, Sec. VI). In this case the shock front is moving left, and it is desired to maintain the boundary conditions at a more or less constant R_{Jmax}. Zones are inserted at the right hand boundary when it is possible to insert between R^n_{jmax} and R^o_{jmax} a zone of the same mass as the right-most zone, at the density specified by RBOUND. A zone will also be inserted if $R^n_{jmax} \leq$ the DR specified in the COMBINATION card. In this case the added zone mass will be exactly enough to make the new $R_{jmax} = R^o_{jmax}$. The flag indicating that the form of combination is desired is a negative J_ℓ whose absolute value is the total number of zones to be permitted in the problem. JO, JOS, JOM have the same meaning as in the previous case. Combining starts when $\hat{j}$ reaches $|j\ell|$ zones. $\hat{j}$ will always equal j_{max} in this case since all zones must always be calculated, so Z2 must be chosen accordingly.

ZTEMPERATURE Card

Zones with temperatures greater than or equal to Z2 will be included in the hydrodynamics calculation. Zones with temperatures greater than or equal to Z1 will be included in the radiation calculations. However hydrodynamic calculations will be done for all zones which are included in the radiation calculations, i.e., $\hat{j}$ is forced to be greater than j^*. When $T_{j\ell}$ is greater than or equal to Z2, i.e. when $\hat{j} = j\ell$, combining and adding of zones is initiated. JL= is the label for $j\ell$. If this card is omitted, Z1=Z2=-1, and $j\ell$=jmax+1, are assumed. For hydrodynamics-only problems Z2 may be a velocity rather than a temperature. Zone j is included in the calculation if $U_{j-1} \geq Z2$. If this is chosen, deck JHTU must be used instead of deck JHTT in both the Generator and Executor sections.

PERCENTS Card

The X's are convergence criteria with the exception of X5, which is a control on the relative size of doubled zones.

X1 is the convergence criterion for zones with $\hat{j} \geq j > j^*$. It occurs in subroutine ROE. T is considered to have converged when

$$\delta T_j \leq X1 \cdot T_j. \tag{82}$$

X2 is the L convergence criterion in subroutine RDI. L is considered to have converged when

$$\delta L_j \leq X2 \cdot L_j. \tag{83}$$

X3 is the T convergence criterion in subroutine RDI. T is considered to have converged when

$$\delta T_j \leq X3 \cdot T_j. \tag{84}$$

X4 is the convergence criterion for T in subroutine GETVAR. T is considered to have converged when

$$\delta T_j \leq X4 \cdot T_j. \tag{85}$$

X5 is a limit on the relative size on doubled zones. Only zones which meet the requirement

$$R_{jo+2} - R_{jo} \leq X5 \cdot R_{\hat{j}} \tag{86}$$

will be doubled.

X6 is the convergence criterion for E in ROA, ROAEXP and ROAIMP. E is considered to have converged when

$$\delta E_j \leq X6 \cdot E_j. \tag{87}$$

The suggested values for X1 through X6 are:

X1 = $.2 \times 10^{-5}$

X2 = $.8 \times 10^{-5}$

X3 = $.4 \times 10^{-5}$

X4 = $.2 \times 10^{-5}$

X5 = .1

X6 = $.2 \times 10^{-3}$

ENDATA Card

ENDATA must be the last card.

Input card formats (MAP version)

	Cols 1–12	13–15	16–27	28–30	31–42	43–45	46–57	58–60	61–72	73–80
	START IHYD	NS=		NF=						
or	HISTORY EDIT	ND=		NC=		ND=		NC=		
	HISTORY EDIT	DT=		CT=		DT=		CT=		
	PRINT OUT		Same format as history edit card							
	ENERGY EDIT		Same format as history edit card							
	TIME STEP	DT=	initial ½Δt	DT=	initial Δt					
	UNITS MMEGMS									
	UNITS CGS									
or *	PLANE GEOMETRY									
or	CYLINDRICAL GEOMETRY									
	SPHERICAL GEOMETRY									
*	RMIN	R=								
*	EOS	O=	idno	1=	idno	2=	idno	3=	idno	
	REGION m	J=		RH=		U=		C1=		
		C2=		C3=		C4=		C5=		
		EO=		T=		R=				
*	ZONE n	DR=		T=		P=				
*	ZONE n	DR=		U=		T=		V=		
*	ZONE l	R=		E=		P=		M=		
or *	ZSOURCE j	E=		TM=		E=		TM=		
*	RSOURCE r	E=		TM=		E=		TM=		
*	BOUNDARY MIN	U=		TM=		U=		TM=		
*	BOUNDARY MAX	P=		TM=		P=		TM=		
*	COMBINATION	JO=		JS=		JM=		DR=		

1-6	7-12	13-15	16-27	28-30	31-42	43-45	46-57	58-60	61-72	73-80
ZTEMPE	RATURE	Z1=		Z2=		JL=				
PERCEN	TS	X1=		X2=		X3=		X4=		
		X5=		X6=						
ENDATA										

Fixed and floating point variable labels must be left adjusted.

All floating point quantities in (E12.6) format

All fixed point quantities are right adjusted and in (I12) format except cols. 7-12. The contents of cols. 7-12 when data is input are in fixed point (I6) format and right adjusted.

For example:

1-6	7-12	13-15	16-27	28-30	31-42
		J=	200	DR=	1. +02

Format for all Generate data cards in the FORTRAN version is (A6, F6.0, 4(A3, E12.6))
All variable names must be left adjusted, i.e., the information in cols. 13-15, 28-30, 43-45, 58-60

	1-6	7-12	13-15	16-27	28-30	31-42	43-45	46-57	58-60	61-72	73-80
	START	IHYD	NS=		NF=						
or	HISTOR		ND=		NC=		ND=		NC=		
	HISTOR		DT=		CT=		DT=		CT=		
	PRINT			Same format as history edit card							
	ENERGY			Same format as history edit card							
	TIME S		DT=	initial ½Δt	DT=	initial Δt		Column 5 must be blank			
*	PLANE										
or	CYLIND										
or	SPHERE										
*	RMIN		R=								
*	EOS		O=	idno	1=	idno	2=	idno	3=	idno	
	REGION	m	J=		RH=		U=		C1=		
			C2=		C3=		C4=		C5=		
			EO=		T=						
*	ZONE	n	DR=		T=		P=				
	ZONE	1	R=		E=		P=		M=		
*	ZSOURC	j	E=		TM=		E=		TM=		
or *	RSOURC	IR	E=		TM=		E=		TM=		
*	BOUNDA	0	U=		TM=		U=		TM=		
*	BOUNDA	1	P=		TM=		P=		TM=		
*	COMBIN		JO=		JS=		JM=		DR=		
	ZTEMPE		Z1=		Z2=		JL=				
	PERCEN		X1=		X2=		X3=		X4=		
			X5=		X6=						
	ENDATA										

COMMENTS ON INPUT CARDS

All cards marked with an asterisk need not be present unless the information they provida is different from the usual initial conditions.

E.g., Plane geometry is assumed if there is no geometry card

RMIN is assumed to be zero if there is no RMIN card

EOS card is used only when tabular EOS are present

ZONE card is necessary if variables are not constant throughout a region

ZSOURCE and/or RSOURCE cards are needed to specify which zone and/or region you are putting energy into.

BOUNDARY 0 and/or BOUNDARY 1 cards must be present only if minimum and/or maximum boundary conditions are desired.

COMBINATION card is not necessary if you do not want to combine zones.

The variables appearing on the region and zone cards (with the exception of C1 thru C5) are not standard but merely examples. The same is true of the labels on the boundary cards.

In the All-FORTRAN version all fixed point variables (i.e., those whose names begin with I,J,K,L,M,N) are read in as F6.0 or E12.6 formats. The result is the number you input on the data card is truncated to assume a fixed point value. To assure yourself of the correct value, therefore, it is wise to input these variables as numbers of the form X.1. For example J=30.1 becomes J=30 via internal truncation.

RESTARTING WITH ALTERING OF ANY CONSTANTS

It is possible to alter any of the constants without regenerating the problem. To do this, one takes advantage of the restart option of the Generator section. Alteration of zone variables or rezoning of the problem is not permitted however.

Restarting may be done from any cycle on the history tape.

The START card must be present for restarts. The problem will be restarted from the first cycle with a cycle number greater than or equal to NS or the last cycle on the tape if NS is very large. NF must also be specified. NS may not be 0 for a restart. To restart from cycle 0 set NS to any negative number.

HISTORY EDIT, PRINT OUT, ENERGY EDIT, and TIME STEP cards may be included as desired.

GEOMETRY, RMIN and EOS cards may not be included.

REGION cards may be included to alter C1, C2, C3, C4, C5 and/or E0, but no rezoning or redefining of zone variables is permitted. The m on restart REGION cards is the region number of the region being altered, not its material number.

ZONE cards will have no effect.

RSOURCE and ZSOURCE cards may be included. If, however, any RSOURCE or ZSOURCE card is included, all the source cards of that particular type must be included, not just the one to be added or altered.

BOUNDARY, COMBINATION, ZTEMPERATURE, and PERCENTS cards may be included as desired. Only those constants or variables which are to be altered need be specified.

The ENDATA card must be present.

EQUATION OF STATE (EOS) HANDLING

Equations of state may be either analytic or tabular or both. There may be a maximum of six of either type.* Those regions which have materials whose equations of state are analytic must use material numbers between 1000 and 1005 inclusive; those which have materials whose equations of state are tabular must use material numbers between 0 and 5 inclusive.

*i.e., a possible total of 12 unique equations of state.

Analytic equations of state are introduced through function type subroutines with names FP100x, FE100x and FK100x for P(T,V), E(T,V) and K(T,V) respectively where x is one of the integers 0, 1,... 5. Only subroutines with names corresponding to material numbers 1000 through 1005 on REGION cards need be included. For example, if the material number 1003 were assigned to a particular region having an analytic equation of state, the form of the subroutine calculating P(T,V) would be

```
1      8
$IBFTC FP1003
       FUNCTION FP1003(T,V)
       FP1003 = some expression using T and V
       RETURN
       END
```

and the form of the subroutines calculating E(T,V) and K(T,V) would be similar. Problems with hydrodynamics only do not require the K(T,V) function subroutine if IHYD on the START card is non-zero.

For problems with hydrodynamics only, a variation of analytic equations is permitted. Instead of providing equations of state of the form P(T,V), E(T,V) and K(T,V), the two equations of state P(E,V) and T(E,V) may be used. Regions with equations of state of this form must use material numbers 2000, 2001, ..., 2005. The function subroutine calculating P(E,V) for a region with material number 200x has the name FP100x, and the subroutine calculating T(E,V) has the name FE100x.

For tabular equations of state it is assumed that a binary tape has previously been prepared by TABCOE and is now mounted as FORTRAN logical tape 8.

The T's, ρ's and interpolation coefficients for equations of state with idno's specified by the EOS card are read into storage. All storage which is not used by subroutines is automatically made available for tables (RAND version only). All-FORTRAN users must dimension their own values for C and LIMIT in GMAIN.

If more storage space is required for equations of state and the problem does not require 200 zones, more storage can be made available. See subroutine COMSIZ, page 127, for this technique.

GENERATE SECTION COMMONS AND INTEGER GROUP NOTES

```
C        ON THE CONTINUATION CARD 9 OF COMMON /IKA1A/, LABELS FOR *,**,***
C     1 ARE IN GENRAT, STREAD, REGNRD, ZONGEN AND PEX ONLY.  RESTRT USES
C     2 * AND **.  ALL OTHER SUBROUTINES DO NOT USE *, ** OR *** LABELS.
C     3   LABELS DEFINED AS    *= RMAX.  **=N.  ***=IHYD.
```

THE FOLLOWING GROUPS OF CARDS SHOULD REPLACE THE COMMENTS CARDS WHICH ARE USED IN THE LISTINGS FOR THE SUBROUTINES.

```
C        THE COMMON /IKA1/ GROUP IS AS FOLLOWS

       COMMON /IKA1/ CARD(12),WLAB,DMVAL,EVAL,KVAL,PVAL,RHVAL,RVAL,TVAL,
      1 UVAL,VVAL,UZAL,TZAL,DMZAL,VZAL,RHZAL,PZAL,EZAL,KZAL,DR,FIELDN,
      2 ERFLAG,CYCSW,NZONE,JCRIG,RGNSW,ZNSWC,ZGETSW,C1SWCH,C3SWCH,C4SWCH,
      3 DRSWCH,EOSWCH,ESWCH,JSWCH,KSWCH,MSWCH,PSWCH,RHSWCH,RSWCH,TSWCH,
      4 USWCH,VSWCH,DRZWCH,EZWCH,KZWCH,MZWCH,PZWCH,RHZWCH,RZWCH,TZWCH,
      5 UZWCH,VZWCH,ZNQSW,BDRYSW,BTYPE,COMSW,ZTEMSW,PERCSW

C        THE COMMON /IKA1A/ GROUP IS AS FOLLOWS

        COMMON /IKA1A/ERS(6,10), ES(6,10), TMRS(6,10), TMS(6,10), RS(10),
      1 JS(10), NRS(10), NZS(10), RRG(15), JREG(15), C1(15), C2(15),
      2 C3(15), C4(15), C5(15), E0(15), EMIN(6), EMAX(6), KMIN(6),
      3 KMAX(6), PMIN(6), PMAX(6), TMIN(6), TMAX(6), UMIN(6), UMAX(6),
      4TEMIN(6), TEMAX(6), TKMIN(6), TKMAX(6), TPMIN(6), TPMAX(6), NKMAX,
      5 TTMIN(6), TTMAX(6), TUMIN(6), TUMAX(6), NEMIN, NEMAX, NKMIN,
      6 NPMIN, NPMAX, NTMIN, NTMAX, NUMIN, NUMAX, NRSRCE, NZSRCE,
      7 J0, JOS, JOM, DRC, Z1, Z2, JL, X1, X2, X3, X4, X5, X6, NS,NF,
      8 UNCGS, UNMKS, TM, DT, DTP, JSTAR, JHAT, JMAX, DELTA, REGNO, JZ,
      9 NREG, NEOS, RMIN,*,**,***

C        THE COMMON /IKA1B/ GROUP IS AS FOLLOWS

        COMMON /IKA1B/ NDH(6), NHC(6), DTH(6), CTH(6), NDP(6), NPC(6),
      1  DTPR(6), CTP(6), NDCK(6), NCKC(6), DTCK(6), CTCK(6)

C        INTEGER GROUP IS AS FOLLOWS

       INTEGER FIELDN,ERFLAG,CYCSW,RGNSW,ZNSWC,ZGETSW,C1SWCH,C3SWCH,
      1 C4SWCH,DRSWCH,EOSWCH,ESWCH,PSWCH,RHSWCH,RSWCH,TSWCH,USWCH,VSWCH,
      2 EZWCH,PZWCH,RHZWCH,TZWCH,UZWCH,VZWCH,ZNQSW,BDRYSW,BTYPE,COMSW,
      3 ZTEMSW,PERCSW,DELTA,REGNO,UNCGS,UNMKS
```

SUBROUTINE DESCRIPTION

1.	COMSIZ						
2.	HOLWD						
3.	GMAIN						
4.		GENRAT					
5.			STREAD				
6.			RESTRT				
7.			CYCRED				
8.			TMREAD				
✓9.			UNTRED				
10.			GEOM				
11.			RMREAD				
12.			EOSNRD				
13.				REOST			
14.			REGNRD				
15.				ZNGET			
16.				GRIDGN			
17.				ZONGEN			
18.					PEK		
19.						FINDC	
20.						ANEOS	
21.							FP100x
22.							FE100x
23.							FK100x
24.					GETVAR		
25.						GTVRTB	
26.					GETTV		
27.			SOURCE				
28.			BOUND				
29.			COMB				
30.			TMPRD				
31.			JHT				
32.			PERC				
✓33.							GETLAB

✓34. CONVRT

✓35. CHGWD

36. IKAERR

37. ALIBI

Check on left at number means deck is not present in FORTRAN version.

The above is a list of the decks which compose the Generator section of HAROLD. The list also indicates the hierarchy of the subroutines in that those routines to the left call those to the right of and immediately below them. GETLAB, CONVRT and CHGWD are called by several of the subroutines, and PEK is used by more subroutines than ZONGEN. The order of subroutines in the deck is not important with the following exceptions: COMSIZ and HOLWD should come first and ALIBI should be last.

Since common statements for most of the subroutines are quite similar, we have replaced them in the listings by comment cards which indicate common groups. The instructions following the subroutine listings describe the necessary common groups to be included in each case.

1. COMSIZ

COMSIZ exists to give the user control over the amount of storage devoted to zone variables. SIZE is a name in COMSIZ which is defined as follows:

```
SIZE EQU    202
```

This EQU pseudo operation results in all zone variables being dimensioned 202, which permits 200 zones (storage must be allowed for boundary conditions at $j=-\frac{1}{2}$ and $j=jmax+\frac{1}{2}$). If more storage space is required for equations of state and the problem does not have 200 zones, SIZE may be equivalenced to the number of zones in the problem plus two. 170 storage cells are saved by reducing the value of SIZE by ten.

This subroutine must occur first in the Generator deck as it defines the size of the control sections for zone variables. All other subroutines have dummy control sections dimensioned 1.

```
$IBFTC COSIZG
      SUBROUTINE COMSIZ
      COMMON /RC/ R(202)
      COMMON /UC/ U(202)
      COMMON /TEMC/ TEM(202)
      COMMON /TAMC/ TAM(202)
      COMMON /VLC/ VL(202)
      COMMON /PRC/ PR(202)
      COMMON /EGC/ EG(202)
      COMMON /KPC/ KP(202)
      COMMON /KMC/ KM(202)
      COMMON /DMASSC/ DMASS(202)
      COMMON /DMESSC/ DMESS(202)
      COMMON /TEMSQC/ TEMSQ(202)
      COMMON /TEM3C/ TEM3(202)
      COMMON /TEM4C/ TEM4(202)
      COMMON /KDMC/ KDM(202)
      COMMON /ELC/ EL(202)
      COMMON /MATC/ MAT(202)
      COMMON /QC/ Q(202)
      END
```

2. HOLWD

HOLWD is a deck of labelled COMMONS containing BCD words necessary for interpretation of input card labels. It must be loaded second so that the COMMONS will be properly established. It is never called.

```
$IBFTC HOLWD    REF
      SUBROUTINE HOLWD
      COMMON /PNTB/ PRINTB
      COMMON /ZURC/ ZSOURC
      COMMON /RURC/ RSOURC
      COMMON /ERGY/ ENERGY
      COMMON /TEBS/ TIMEBS
      COMMON /UTSB/ UNITSB
      COMMON /PNEB/ PLANEB
      COMMON /CIND/ CYLIND
      COMMON /ZEBB/ ZONEBB
      COMMON /RION/ REGION
      COMMON /SERI/ SPHERI
      COMMON /STRB/ STARTB
      COMMON /HTOR/ HISTOR
      COMMON /DQ/ DTQ
      COMMON /BYBB/ BDRYBB
      COMMON /RNBB/ RMINBB
      COMMON /RXBB/ RMAXBB
      COMMON /CBIN/ COMBIN
      COMMON /ZMPE/ ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /EATA/ ENDATA
      COMMON /BDEB/ BRODEB
      COMMON /CGBB/ CGSBBB
      COMMON /MKBB/ MKSBBB
      COMMON /NQ/ NSQ,NFQ
      COMMON /NEQ/ NCE,NDE,DTF,CTE
```

```
COMMON /BLNK/ BLANK
COMMON /RQ/ REQ
COMMON /JQ/ JEQ
COMMON /VQ/ VEQ
COMMON /DRQ/ DREQ
COMMON /UQ/ UEQ
COMMON /TQ/ TEQ
COMMON /MQ/ MEQ
COMMON /RHQ/ RHEQ
COMMON /PQ/ PEQ
COMMON /EQ/ EEQ
COMMON /KQ/ XEQ
COMMON /C1Q/ C1EQ
COMMON /C2Q/ C2EQ
COMMON /C3Q/ C3EQ
COMMON /C4Q/ C4EQ
COMMON /C5Q/ C5EQ
COMMON /E0Q/ E0EQ
COMMON /TMQ/ TMEQ
COMMON /MNMX/ MINBB,MAXBB
COMMON /X1Q/ X1EQ
COMMON /X2Q/ X2EQ
COMMON /X3Q/ X3EQ
COMMON /X4Q/ X4EQ
COMMON /X5Q/ X5EQ
COMMON /X6Q/ X6EQ
COMMON /Z1Q/ Z1EQ
COMMON /Z2Q/ Z2EQ
COMMON /JLQ/ ZJLEQ
COMMON /JMEQ/ ZJMEQ
COMMON /JSEQ/ ZJSEQ
COMMON /JZEQ/ ZJOEQ
COMMON /ESO/ EOS(7)
DATA PRINTB/6HPRINT /
DATA ZSOURC/6HZSOURC/
DATA RSOURC/6HRSOURC/
DATA ENERGY/6HENERGY/
DATA TIMEBS/6HTIME S/
DATA UNITSB/6HUNITS /
DATA PLANEB/6HPLANE /
DATA CYLIND/6HCYLIND/
DATA ZONEBB/6HZONE  /
DATA REGION/6HREGION/
DATA SPHERI/6HSPHERI/
DATA STARTB/6HSTART /
DATA HISTOR/6HHISTOR/
DATA DTQ/6HDT=    /
DATA BDRYBB/6HBOUNDA/
DATA RMINBB/6HRMIN  /
DATA RMAXBB/6HRMAX  /
DATA COMBIN/6HCOMBIN/
DATA ZTEMPE/6HZTEMPE/
DATA PERCEN/6HPERCEN/
DATA ENDATA/6HENDATA/
DATA BRODEB/6HMMEGMS/
DATA CGSBBB/6HCGS   /
DATA MKSBBB/6HMKS   /
```

```
      DATA NSQ,NFQ/6HNS=    ,6HNF=    /
      DATA NCE,NDE,DTE,CTE/6HNC=    ,6HND=    ,6HDT=    ,6HCT=    /
      DATA BLANK/6H          /
      DATA REQ/6HR=          /
      DATA JEQ/6HJ=          /
      DATA VEQ/6HV=          /
      DATA DREQ/6HDR=        /
      DATA UEQ/6HU=          /
      DATA TEQ/6HT=          /
      DATA MEQ/6HM=          /
      DATA RHEQ/6HRH=        /
      DATA PEQ/6HP=          /
      DATA EEQ/6HE=          /
      DATA KEQ/6HK=          /
      DATA C1EQ/6HC1=        /
      DATA C2EQ/6HC2=        /
      DATA C3EQ/6HC3=        /
      DATA C4EQ/6HC4=        /
      DATA C5EQ/6HC5=        /
      DATA EOEQ/6HEO=        /
      DATA TMEQ/6HTM=        /
      DATA MINBB,MAXBB/6HMIN    ,6HMAX    /
      DATA X1EQ/6HX1=        /
      DATA X2EQ/6HX2=        /
      DATA X3EQ/6HX3=        /
      DATA X4EQ/6HX4=        /
      DATA X5EQ/6HX5=        /
      DATA X6EQ/6HX6=        /
      DATA Z1EQ/6HZ1=        /
      DATA Z2EQ/6HZ2=        /
      DATA ZJLEQ/6HJL=       /
      DATA ZJSEQ/6HJS=       /
      DATA ZJOEQ/6HJO=       /
      DATA ZJMEQ/6HJM=       /
      DATA EOS(1),EOS(2),EOS(3),EOS(4),EOS(5),EOS(6),EOS(7)/6HEOS    ,
     1 6HO=    ,6H1=    ,6H2=    ,6H3=    ,6H4=    ,6H5=    /
      END
```

3A. GMAIN (All-FORTRAN version)

C and LIMIT are dimensioned for the number of cells required for tabular equations of state being used.

3B. GMAIN (RAND version)

GMAIN is the deck in which execution of the Generator begins. It is also the entry point for the Generator. It determines from S.SLOC+4* the address of the first location not used by the program and establishes this location as the first location of the tabular

*IBM Systems Reference library form C28-6339, 1963, p. 59.

equation of state coefficient table. It also determines from S.SLOC+3 the number of cells required for I/O buffers and from this it calculates the number of cells available for this coefficient table. This number is stored as LIMIT.

```
$IBFTC GMAIN   REF
      DIMENSION C(2000)
      LIMIT = 2000
      CALL HOLWD
      CALL GENRAT(C,LIMIT)
      CALL EXIT
      END
```

4. GENRAT (C,LIMIT)

GENRAT is the main controlling routine of the Generator. It calls subroutines for the reading and interpreting of input cards, writes the generated problem on the history tape and prints.

```
$IBFTC GENRAT  REF
      SUBROUTINE GENRAT(C,LIMIT)
C     COMMON CARDS LABELED /IKA1/,/IKA1A/ AND /IKA1B/ GROUPS AND
C    1  INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
       COMMON /RC/ R(1)
      COMMON /UC/ U(1)
      COMMON /TEMC/ TEM(1)
      COMMON /TAMC/ TAM(1)
      COMMON /VLC/ VL(1)
      COMMON /PRC/ PR(1)
      COMMON /EGC/ EG(1)
      COMMON /KPC/ KP(1)
      COMMON /KMC/ KM(1)
      COMMON /DMASSC/ DMASS(1)
      COMMON /DMESSC/ DMESS(1)
      COMMON /TEMSQC/ TEMSQ(1)
      COMMON /TEM3C/ TEM3(1)
      COMMON /TEM4C/ TEM4(1)
      COMMON /KDMC/ KDM(1)
      COMMON /ELC/ EL(1)
       COMMON /CKCOM/ CKY(15)
      COMMON /MATC/ MAT(1)
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
      COMMON /STRB/ STARTB
       COMMON /SUM2C / SUM2(15)
      COMMON /FATA/ ENDATA
       COMMON / QC / Q(1)
       DIMENSION C(1)
      WRITE (6,2)
```

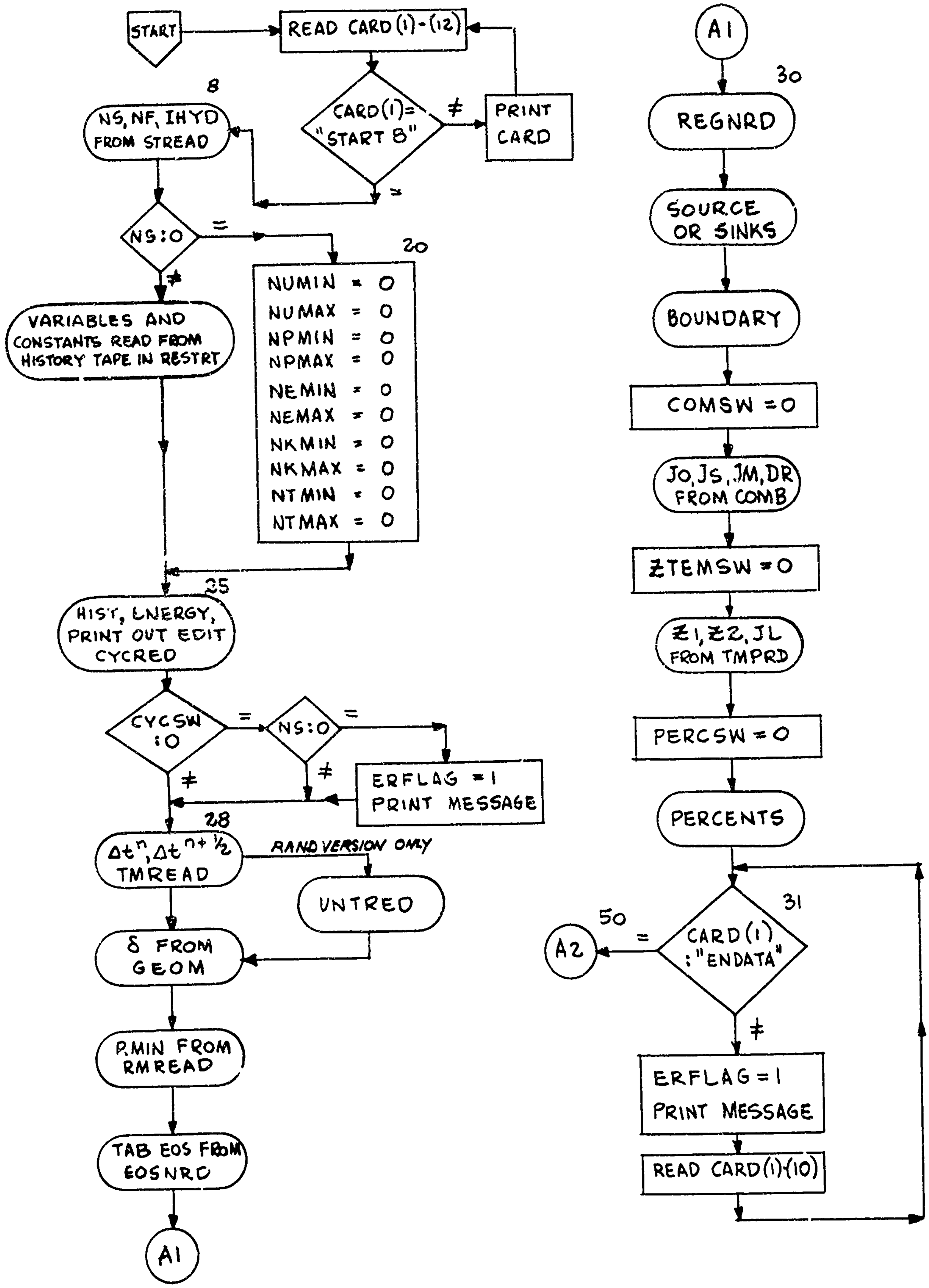
```
    2  FORMAT (1H1 )
       READ (5,3) NODOC
    3  FORMAT (I6)
       IF (NODOC.EQ.0) GO TO 7
       DO 6 III=1,NODOC
       READ (5,5) (CARD(I),I=1,12)
    5  FORMAT (12A6)
    6  WRITE (6,9) (CARD(I),I=1,12)
    9  FORMAT (1H ,12A6)
    7  READ(5,7025) (CARD(I),I=1,10)
 7025  FORMAT (A6,F6.0,4(A3,E12.6))
    8  CALL STREAD
       IF (NS.EQ.0) GO TO 20
       CALL RESTRT
       GO TO 25
 20    NUMIN=0
       NUMAX=0
       NPMAX=0
       NPMIN=0
       NEMIN=0
       NEMAX=0
       NKMAX=0
       NKMIN=0
       NTMAX=0
       NTMIN=0
 25    CALL CYCRED
       IF (CYCSW.NE.0) GO TO 28
       IF (NS.NE.0) GO TO 28
       ERFLAG=1
       WRITE (6,10)
       WRITE (6,7025) (CARD(I),I=1,10)
   10  FORMAT (1H0,47H GENRAT FRMT10  MUST HAVE AN EDIT SPECIFICATION ,
      111H WHEN NS=0.  /)
   28  CALL TMREAD
       CALL GEOM
       CALL RMREAD
       CALL EOSNRD(C,LIMIT)
       ZGETSW = 0
   30  CALL REGNRD(C)
       CALL SOURCE
       CALL BOUND
       COMSW=0
       CALL COMB
       ZTEMSW=0
       CALL TMPRD
       PERCSW=0
       CALL PERC
   31  IF (CARD(1).EQ.ENDATA) GO TO 50
       ERFLAG=1
       WRITE (6,1000)
       WRITE (6,7025) (CARD(I),I=1,10)
```

```
1000 FORMAT (1H0,37H GENRAT FRMT1000  ENDATA EXPECTED NOW /)
     READ (5,7025) (CARD(I),I=1,10)
     GO TO 31
 50   IF(NS.GT.0) GO TO 49
      IR=1
      J=1
 48   SUM2(IR)=0.
 42   IF (EO(IR).GT.0.) GO TO 43
      IF (EO(IR).LT.0.) GO TO 45
      EZ=EG(J+1)
      GO TO 47
 43   EZ=EO(IR)
      GO TO 47
 45   JEO=JREG(IR)+1
      EZ= EG(JEO)
 47   SUM2(IR)=SUM2(IR)+EZ*DMASS(J+1)
      J=J+1
      IF (J.LE.JREG(IR)) GO TO 42
      IR=IR+1
      IF (IR.GT.NREG) GO TO 49
      GO TO 48
 49   J2=JREG(NREG)+1
     DO 41 J=2,J2
 200 DELT=DELTA
 215 IF (DELTA.GT.1) GO TO 218
     D=R(J)-R(J-1)
     GO TO 240
 218 IF (DELTA.GT.2) GO TO 220
     D=(R(J)-R(J-1))*(R(J)+R(J-1))
     GO TO 240
 220 D=(R(J)-R(J-1))*(R(J)**2+R(J)*R(J-1)+R(J-1)**2)
 240 VL(J)=D/DELT/DMASS(J)
  41 CONTINUE
     PRINT 7000
7000 FORMAT(10H1HISTORYS.)
     IF(NDH(1).EQ.0) GO TO 51
     PRINT 7001,(NDH(I),NHC(I),I=1,6)
7001 FORMAT(6H EVERYI6,19H CYCLES UNTIL CYCLEI6)
     GO TO 52
  51 PRINT 7002,(DTH(I),CTH(I),I=1,6)
7002 FORMAT(6H EVERYE16.7,13H MSECS. UNTILE16.7,7H MSECS.)
  52 PRINT 7003
7003 FORMAT(12H0PRINT OUTS.)
     IF(NDP(1).EQ.0) GO TO 53
     PRINT 7001,(NDP(I),NPC(I),I=1,6)
     GO TO 54
  53 PRINT 7002,(DTPR(I),CTP(I),I=1,6)
  54 PRINT 7004
7004 FORMAT(15H0ENERGY CHECKS.)
     IF(NDCK(1).EQ.0) GO TO 55
     PRINT 7001, (NDCK(I),NCKC(I),I=1,6)
     GO TO 56
```

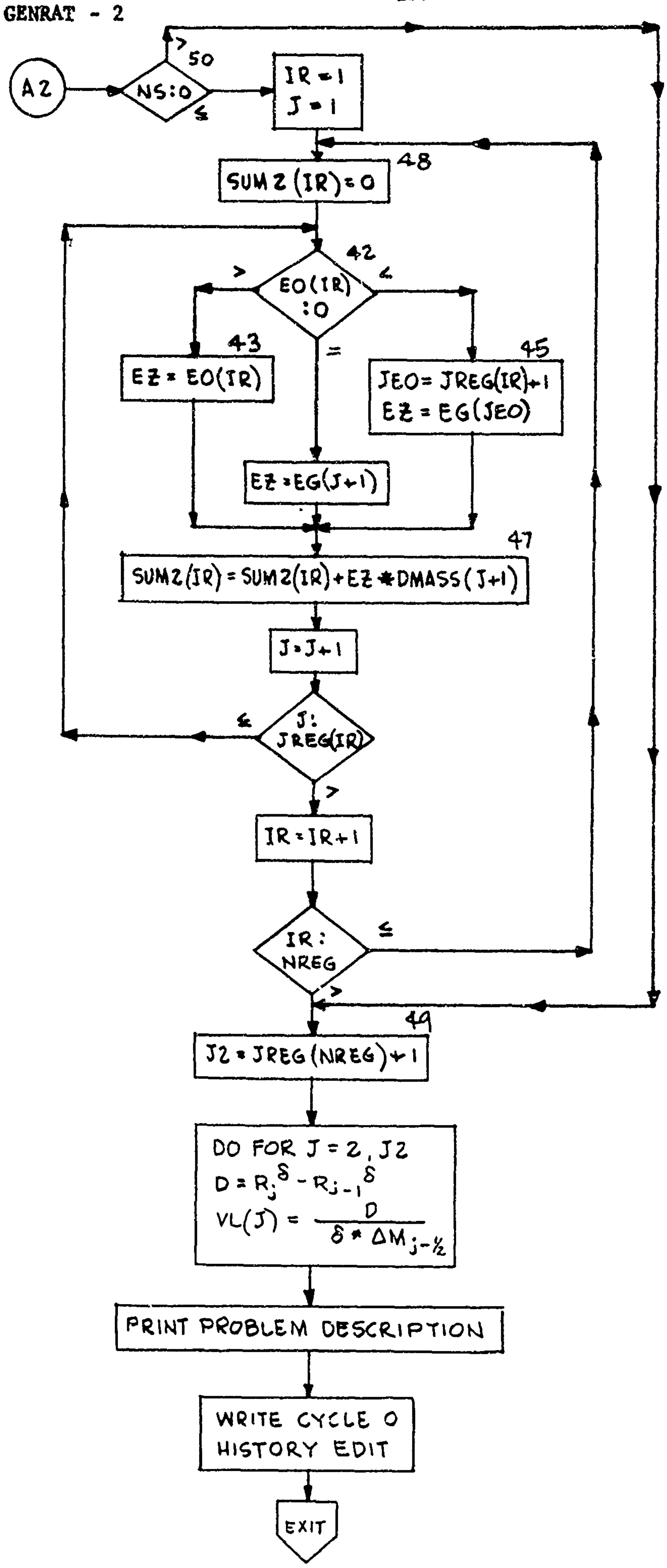
```
   55 PRINT 7002, (DTCK(I),CTCK(I),I=1,6)
   56 IF(NEMIN.EQ.0) GO TO 57
      PRINT 7005,(EMIN(I),TEMIN(I),I=1,NEMIN)
 7005 FORMAT(20HOEMIN BNDRY COND. E=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7006 FORMAT(20HOKMIN BNDRY COND. K=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7007 FORMAT(20HOPMIN BNDRY COND. P=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7008 FORMAT(20HOTMIN BNDRY COND. T=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7009 FORMAT(20HOUMIN BNDRY COND. U=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7010 FORMAT(20HOEMAX BNDRY COND. E=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7011 FORMAT(20HOKMAX BNDRY COND. K=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7012 FORMAT(20HOPMAX BNDRY COND. P=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7013 FORMAT(20HOTMAX BNDRY COND. T=/(E16.7,6H UNTILE16.7,7H MSECS.))
 7014 FORMAT(20HOUMAX BNDRY COND. U=/(E16.7,6H UNTILE16.7,7H MSECS.))
   57 IF(NKMIN.EQ.0) GO TO 58
      PRINT 7006,(KMIN(I),TKMIN(I),I=1,NKMIN)
   58 IF(NPMIN.EQ.0) GO TO 59
      PRINT 7007,(PMIN(I),TPMIN(I),I=1,NPMIN)
   59 IF(NTMIN.EQ.0) GO TO 60
      PRINT 7008,(TMIN(I),TTMIN(I),I=1,NTMIN)
   60 IF(NUMIN.EQ.0) GO TO 61
      PRINT 7009,(UMIN(I),TUMIN(I),I=1,NUMIN)
   61 IF(NEMAX.EQ.0) GO TO 62
      PRINT 7010,(EMAX(I),TEMAX(I),I=1,NEMAX)
   62 IF(NKMAX.EQ.0) GO TO 63
      PRINT 7011,(KMAX(I),TKMAX(I),I=1,NKMAX)
   63 IF(NPMAX.EQ.0) GO TO 64
      PRINT 7012,(PMAX(I),TPMAX(I),I=1,NPMAX)
   64 IF(NTMAX.EQ.0) GO TO 65
      PRINT 7013,(TMAX(I),TTMAX(I),I=1,NTMAX)
   65 IF(NUMAX.EQ.0) GO TO 66
      PRINT 7014,(UMAX(I),TUMAX(I),I=1,NUMAX)
   66 PRINT 7015, RMIN
 7015 FORMAT(6HORMIN=E16.7)
       GO TO (80,81,82), DELTA
   80  PRINT 7027
 7027  FORMAT(16HOPLANE GEOMETRY.)
       GO TO 83
   81  PRINT 7028
 7028  FORMAT(22HOCYLINDRICAL GEOMETRY.)
       GO TO 83
   82  PRINT 7029
 7029  FORMAT(20HOSPHERICAL GEOMETRY.)
   83 IR=1
      J1=1
   67 IF(JREG(IR).EQ.0) GO TO 68
      J2=JREG(IR)
       J3=MAT(J2+1)+1
       J4=MAT(J2+1)
       IF(MAT(J2+1).LT.1000) J4=IDEOS(J3)
      PRINT 7016, IR,J4,C1(IR),C2(IR),C3(IR),C4(IR),C5(IR),E0(IR)
```

```
7016 FORMAT(7HOREGIONI6,10H, MATERIALI6,1H./4H C1=E12.4,5H, C2=E12.4,
    15H, C3=E12.4,5H, C4=E12.4,5H, C5=E12.4,5H, E0=E12.4,1H.)
     PRINT 7017,(J,R(J+1),U(J+1),TEM(J+1),VL(J+1),PR(J+1),EG(J+1),
    1KP(J+1),KM(J+1),DMASS(J+1),EL(J+1),J=J1,J2)
7017 FORMAT(1HO,1HJ,6X,2HR ,10X,2HU ,9X,4HTEM ,8X,4HVL  ,8X,4HPR  ,8X,
    14HEG  ,8X,4HKP  ,8X,4HKM  ,7X,6HDMASS ,7X,2HEL/(1H ,I3,10E12.4))
      IR=IR+1
      IF(IR.GT.15) GO TO 68
      J1=J2+1
     GO TO 67
  68  IF(NRSRCE.EQ.0) GO TO 70
      DO 69 I=1,NRSRCE
      J=NRS(I)
  69  PRINT 7023,RS(I),(ERS(K,I),TMRS(K,I),K=1,J)
7023  FORMAT(25HOSOURCE OR SINK IN REGION   I3/
    1 (9H DELTA E=E16.7,26H X 1.E-10 ERGS/MSEC. UNTILE16.7,7H MSECS.))
  70  IF(NZSRCE.EQ.0) GO TO 72
      DO 71 I=1,NZSRCE
      J=NZS(I)
  71  PRINT 7024, JS(I),(ES(K,I),TMS(K,I),K=1,J)
7024  FORMAT(23HOSOURCE OR SINK IN ZONE  I3/
    1 (9H DELTA E=E16.7,26H X 1.E-10 ERGS/MSEC. UNTILE16.7,7H MSECS.))
  72 PRINT 7018, DT,DTP
7018 FORMAT(4HODT=E16.7,6H, DTP=E16.7,1H.)
     PRINT 7019, J0,JOS,JOM,DRC
7019 FORMAT(15HOMASS ADD INFO./4H J0=I6,6H, JOS=I6,6H, JOM=I6,5H, DR=
    1E16.7,1H.)
     PRINT 7020, X1,X2,X3,X4,X5,X6
7020 FORMAT(10HOPERCENTS./4H X1=E12.4,5H, X2=E12.4,5H, X3=E12.4,5H, X4=
    1E12.4,5H, X5=E12.4,5H, X6=E12.4,1H.)
     PRINT 7021, Z2,JHAT,JL,Z1,JSTAR
7021 FORMAT(4HOZ2=E16.7,7H, JHAT=I6,5H, JL=I6,5H, Z1=E16.7,8H, JSTAR=I6
    1,1H.)
     PRINT 7022, NF
7022 FORMAT(4HONF=I6)
      IF(NS.EQ.0) RMAX=R(JMAX+1)
     NS=N
     WRITE (12) NREG,JMAX,NRSRCE,NZSRCE,NEMIN,NEMAX,NKMIN,NKMAX,NPMIN,
    1 NPMAX,NTMIN,NTMAX,NUMIN,NUMAX,DT,DTP,DELTA,REGNO,NS,NF,JZ,DRC,
    2 Z1,Z2,X1,X2,X3,X4,X5,X6,J0,JOM,JOS,JL,JSTAR,JHAT,UNCGS,UNMKS,
    3 TM,RMIN,RMAX
     JMAX1=JMAX+2
      DUM=0.
     WRITE (12) (R(I),U(I),TEM(I),TAM(I),VL(I),DUM,PR(I),DUM,
    1 EG(I),DUM,KP(I), KM(I),DMASS(I),DMESS(I), TEMSQ(I),TEM3(I),
    2 TEM4(I),KOM(I),EL(I),DUM,MAT(I),Q(I),I=1,JMAX1)
     WRITE(12) (RRG(I),JREG(I),C1(I),C2(I),C3(I),C4(I),C5(I),E0(I),
    1 CKY(I),SUM2(I),I=1,15),MEOS,IDEOS
     WRITE (12) (NDM(I),NMC(I),NDP(I),NPC(I),NDCK(I),NCKC(I),EMIN(I),
    1 EMAX(I),KMIN(I),KMAX(I),PMIN(I),PMAX(I),TMIN(I),TMAX(I),UMIN(I),
    2 UMAX(I),TEMIN(I),TEMAX(I),TKMIN(I),TKMAX(I),TPMIN(I),TPMAX(I),
    3 TTMIN(I),TTMAX(I),TUMIN(I),TUMAX(I),DTM(I),CTM(I),DTPR(I),CTP(I),
    4 DTCK(I),CTCK(I),I=1,6)
     WRITE (12) ((ERS(I,K),ES(I,K),TMRS(I,K),TMS(I,K),I=1,6),RS(K),
    1 JS(K),NRS(K),NZS(K),K=1,10)
     J=123456
      WRITE (12) J
     CALL EXIT
     END
```

GENRAT - 1


START
READ CARD(1)-(12)
CARD(1)= "START B"
≠
=
PRINT CARD
8
NS, NF, IHYD FROM STREAD
NS:0
=
≠
20
NUMIN = 0
NUMAX = 0
NPMIN = 0
NPMAX = 0
NEMIN = 0
NEMAX = 0
NKMIN = 0
NKMAX = 0
NTMIN = 0
NTMAX = 0
VARIABLES AND CONSTANTS READ FROM HISTORY TAPE IN RESTRT
25
HIST, ENERGY, PRINT OUT EDIT CYCRED
CYCSW :0
=
≠
NS:0
=
≠
ERFLAG = 1 PRINT MESSAGE
28
Δt^n, Δt^{n+1/2} TMREAD
RAND VERSION ONLY
UNTRED
δ FROM GEOM
R.MIN FROM RMREAD
TAB EOS FROM EOSNRD
A1
A1
30
REGNRD
SOURCE OR SINKS
BOUNDARY
COMSW = 0
Jo, Js, JM, DR FROM COMB
ZTEMSW = 0
Z1, Z2, JL FROM TMPRD
PERCSW = 0
PERCENTS
31
CARD(1) : "ENDATA"
50
=
A2
≠
ERFLAG = 1
PRINT MESSAGE
READ CARD(1)-(10)

GENRAT - 2

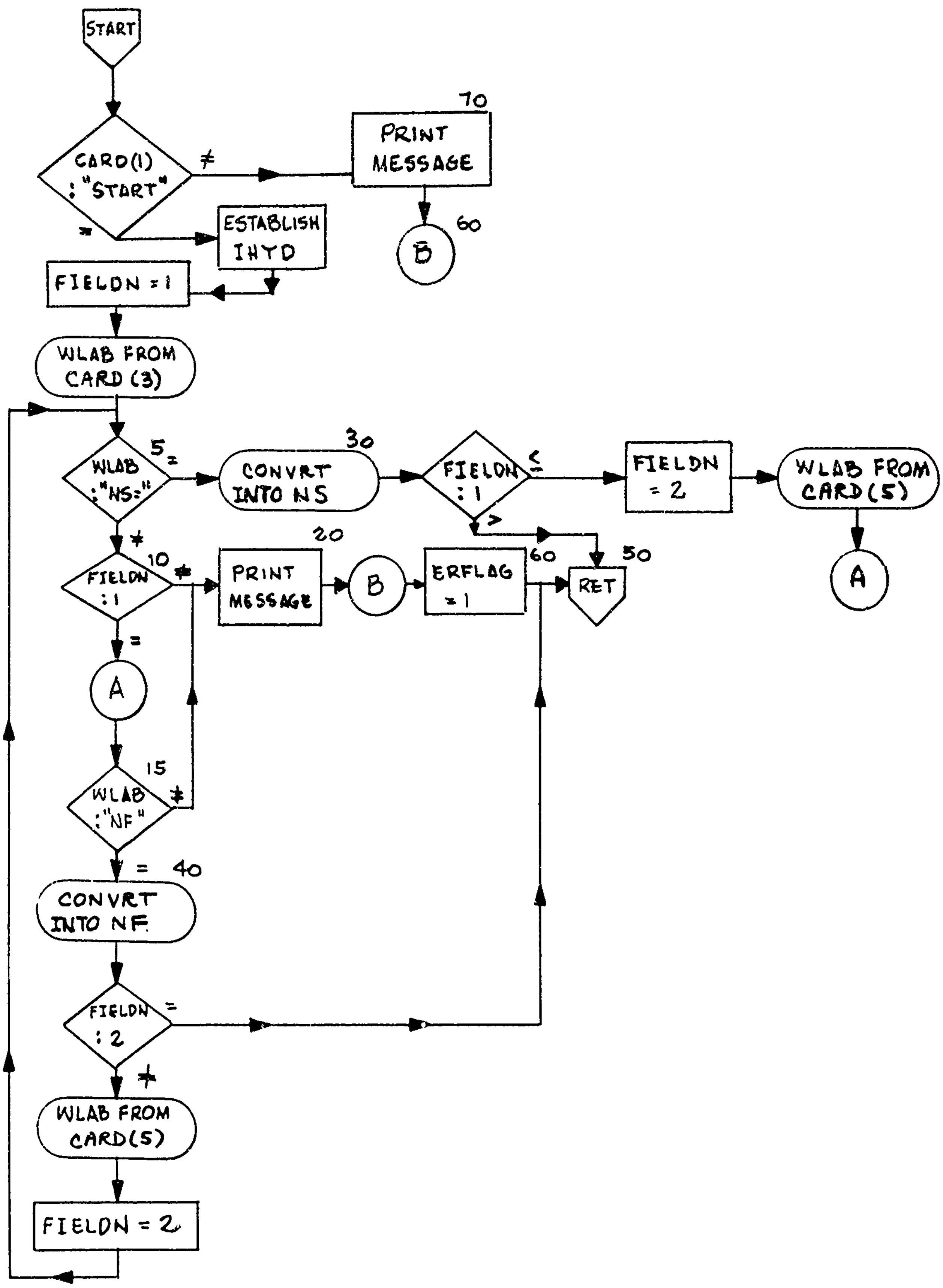

A2
NS:0
> 50
≤
IR = 1
J = 1
48
SUM Z (IR) = 0
42
EO(IR) :0
>
<
=
43
EZ = EO(IR)
45
JEO = JREG(IR)+1
EZ = EG(JEO)
EZ = EG(J+1)
47
SUMZ(IR) = SUMZ(IR)+EZ * DMASS(J+1)
J = J+1
J: JREG(IR)
≤
>
IR = IR+1
IR: NREG
≤
>
49
J2 = JREG (NREG)+1
DO FOR J = 2, J2
D = R_j^δ - R_{j-1}^δ
VL(J) = D / (δ * ΔM_{j-½})
PRINT PROBLEM DESCRIPTION
WRITE CYCLE 0
HISTORY EDIT
EXIT

5. STREAD

STREAD reads and interprets the START card.

```
$IBFTC STREAC  REF
      SUBRCUTINE STREAC
C     COMPCN CARDS LABELEC /IKA1/,/IKA1A/ AND /IKA1B/ GRCUPS ANC
C    1  INTEGER CARD GROUP TC BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KP
      COMMON /STRB/ STARTB
      COMMCN  /NQ/NSQ,NFQ
      REAL NSQ,NFQ
      IF (CARC(1).NE.STARTB) GO TC 70
      IHYC=CARD(2)
      FIELCN=1
      WLAB=CARD(3)
    5 IF (WLAB.EQ.NSQ) GO TO 3C
   10 IF (FIELDN.NE.1) GO TC 20
   15 IF (WLAB.EQ.NFQ) GO TC 4C
   20 WRITE (6,1CCC)
      WRITE (6,7025) (CARD(I),I=1,1C)
 7025  FORMAT (A6,F6.0,4(A3,E12.6))
 1CCC FORMAT (1HC,5CH STREAC FRMT1CCC  THERE IS AN ERRCR IN THE 'STAR'
     1,6H CARC. /)
      GC TC 60
   30 IF (FIELDN.EC.1) NS=CARC(4)
      IF (FIELDN.EC.2) NS=CARC(6)
      IF (FIELDN.GT.1) GO TC 50
      FIELCN=2
      WLAB=CARD(5)
      GO TC 15
   40 IF (FIELDN.EC.1) NF=CARD(4)
      IF (FIELDN.EC.2) NF=CARD(6)
      IF (FIELDN.EC.2) GO TO 50
      WLAB=CARD(5)
      FIELCN=2
      GC TC 5
   60 ERFLAG=1
   5C RETURN
   7C  WRITE (6,1C1C)
      WRITE (6,7025)(CARD(I),I=1,10)
 1010 FORMAT (1H0,41H STREAD FRMT1010  FIRST CARC NOT 'START'. /)
      GC TC 6C
      END
```

STREAD


START
CARD(1) : "START"
≠
=
70
PRINT MESSAGE
60
B
ESTABLISH IHYD
FIELDN = 1
WLAB FROM CARD (3)
5
WLAB : "NS="
=
30
CONVRT INTO NS
FIELDN : 1
≤
>
FIELDN = 2
WLAB FROM CARD (5)
A
≠
10
FIELDN : 1
20
PRINT MESSAGE
B
60
ERFLAG = 1
50
RET
A
15
WLAB : "NF"
40
CONVRT INTO NF
FIELDN : 2
WLAB FROM CARD(5)
FIELDN = 2

6. RESTRT

RESTRT is called if NS is not equal to 0. It locates the first history edit on the history tape with a cycle number greater than or equal to NS, reads this history edit and backspaces over it. An NS larger than any cycle in the history tape results in the last cycle being read.

```
$IBFTC RESTRT  REF
      SUBROUTINE RESTRT
C     COMMON CARDS LABELED /IKA1/,/IKA1A/ AND /IKA1B/ GROUPS AND
C    1  INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
       COMMON /RC/ R(1)
      COMMON /UC/ U(1)
      COMMON /TEMC/ TEM(1)
      COMMON /TAMC/ TAM(1)
      COMMON /VLC/ VL(1)
      COMMON /PRC/ PR(1)
      COMMON /EGC/ EG(1)
      COMMON /KPC/ KP(1)
      COMMON /KMC/ KM(1)
      COMMON /DMASSC/ DMASS(1)
      COMMON /DMESSC/ DMESS(1)
      COMMON /TEMSCC/ TEMSC(1)
      COMMON /TEM3C/ TEM3(1)
      COMMON /TEM4C/ TEM4(1)
      COMMON /KDMC/ KDM(1)
      COMMON /ELC/ EL(1)
       COMMON /CKCCM/ CKY(15)
      COMMON /MATC/ MAT(1)
       COMMON /SUM2C / SUM2(15)
       COMMON / QC / Q(1)
      COMMON /EOSCCM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
    1  READ (12) J
       BACKSPACE 12
       IF(J.EQ.123456) GO TO 10
      READ  (12) NREG,JMAX,NRSRCE,NZSRCE,NEMIN,NEMAX,NKMIN,NKMAX,NPMIN,
     1 NPMAX,NTMIN,NTMAX,NUMIN,NUMAX,DT,DTP,DELTA,REGNC,N,NFT,JZ,DRC,
     2 Z1,Z2,X1,X2,X3,X4,X5,X6,JC,JCM,JCS,JL,JSTAR,JHAT,LNCGS,UNMKS,
     3 TM,RMIN,RMAX
       IF(NS.EQ.0) NF=NFT
       JMAX2=JMAX+2
      READ  (12) (R(I),U(I),TEM(I),TAM(I),VL(I),DUM,PR(I),DUM,
     1 EG(I),DUM,KP    , KM(I),DMASS(I),DMESS(I), TEMSC(I),TEM3(I),
     2 TEM4(I),KDM  ),EL(I),DUM,MAT(I),Q(I),I=1,JMAX2)
      READ (12) (RRC(I),JREG(I),C1(I),C2(I),C3(I),C4(I),C5(I),EC(I),
```

```
     1 CKY(I),SUM2(I),I=1,15),MECS,IDECS
      READ  (12) (NCH(I),NHC(I),NDP(I),NPC(I),NCCK(I),NCKC(I),EMIN(I),
     1 EMAX(I),KMIN(I),KMAX(I),PMIN(I),PMAX(I),TMIN(I),TMAX(I),UMIN(I),
     2 UMAX(I),TEMIN(I),TEMAX(I),TKMIN(I),TKMAX(I),TPMIN(I),TPMAX(I),
     3 TTMIN(I),TTMAX(I),TUMIN(I),TUMAX(I),DTH(I),CTH(I),DTPR(I),CTP(I),
     4 DTCK(I),CTCK(I),I=1,6)
      READ  (12) ((ERS(I,K),ES(I,K),TMRS(I,K),TMS(I,K),I=1,6),RS(K),
     1 JS(K),NRS(K),NZS(K),K=1,10)
      IF(N.GE.NS) GO TO 10
      GO TO 1
   10 DO 15 I=1,5
   15  BACKSPACE 12
      RETURN
      END
```

7. CYCRED

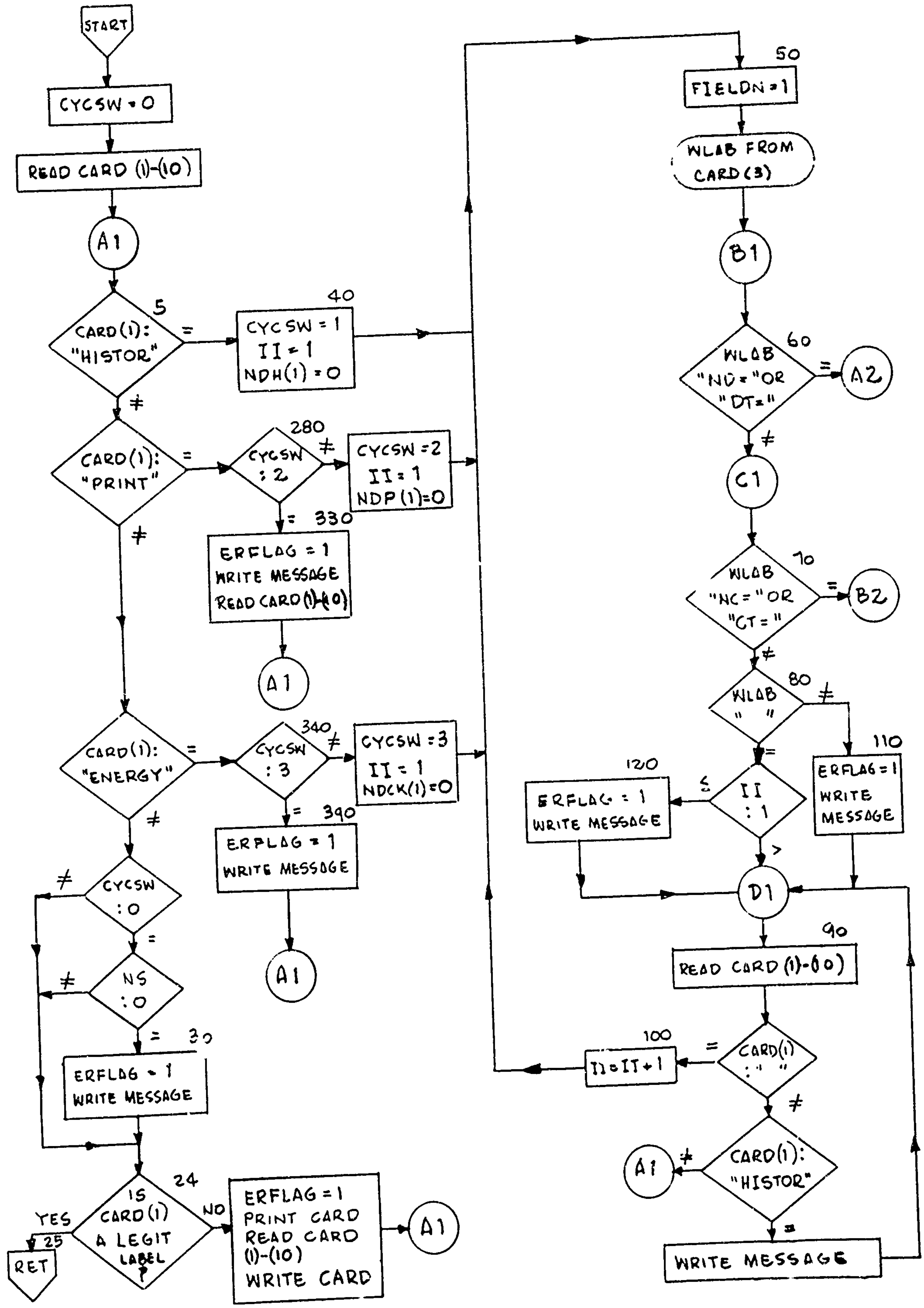
CYCRED reads and interprest the HISTORY EDIT, PRINT OUT, and ENERGY EDIT cards.

```
$IBFTC CYCRED  REF
      SUBROUTINE CYCRED
C     COMMON CARDS LABELED /IKA1/,/IKA1A/ AND /IKA1B/ GROUPS AND
C    1  INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      COMMON /HTOR/HISTOR
      COMMON /PNTB/PRINTB
      COMMON /ERGY/ENERGY
      COMMON /NEQ/NCE,NDE,CTE,CTE
      COMMON /TEBS/ TIMEBS
      COMMON/UTSB/ UNITSB
      COMMON /PNEB/ PLANEB
      COMMON /CINC/ CYLINC
      COMMON/SERI/SPHERI
      COMMON /RNBB/ RMINBB
      COMMON /ESC/ ECS
      COMMON /RION/ REGION
      COMMON /ZEBB/ ZONEBB
      COMMON /ZURC/ ZSOURC
      COMMON /RURC/ RSOURC
      COMMON /BYBB/ BDRYBB
      COMMON /CBIN/ COMBIN
      COMMON /ZMPE/ ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /EATA/ ENDATA
      COMMON /BLNK/BLANK
      REAL NCE,NCE
    1  FORMAT (A6,F6.0,4(A3,E12.6))
      CYCSW=0
      READ (5,1) (CARD(I),I=1,10)
```

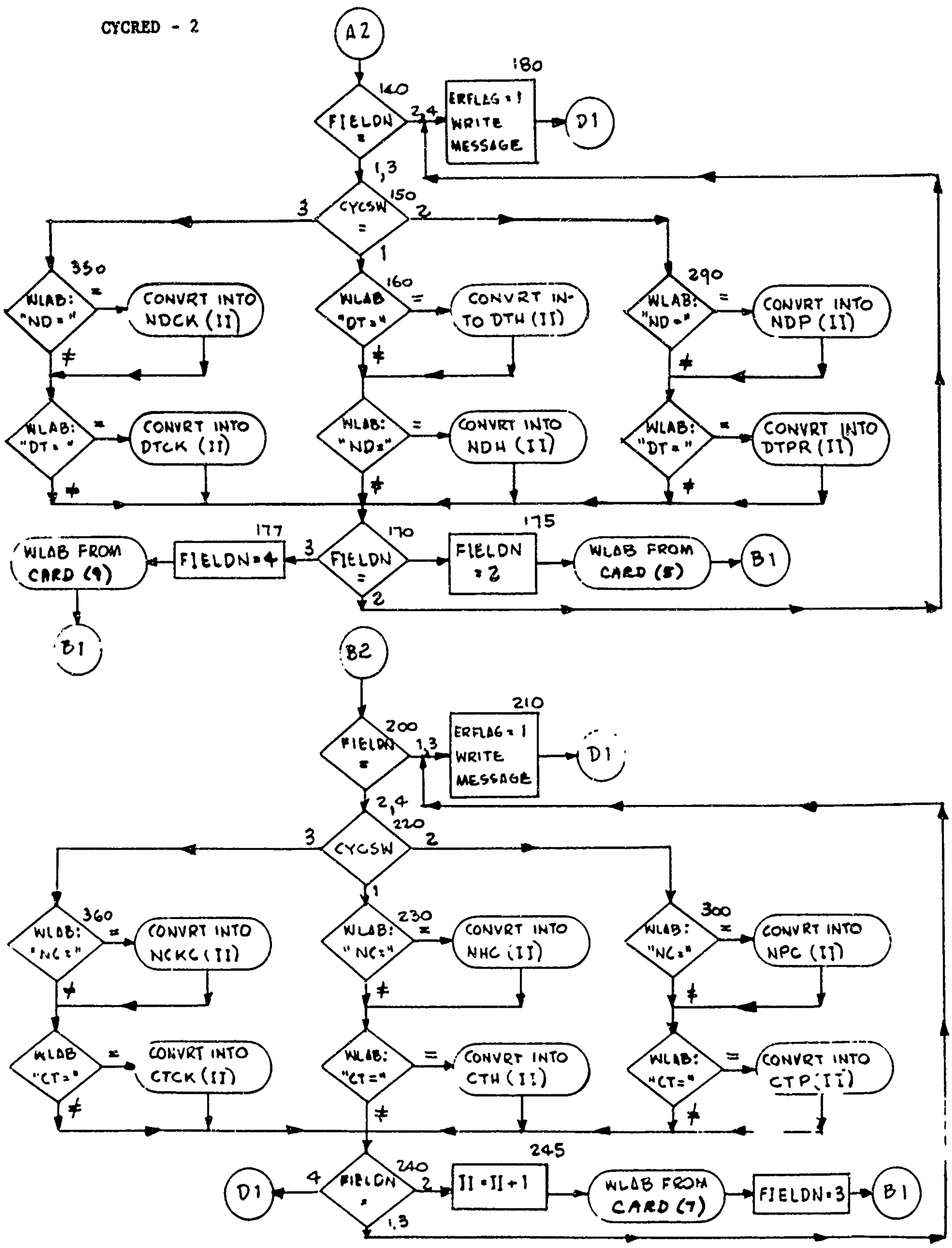
```
5     IF (CARD(1).EQ.HISTOR) GO TO 40
      IF (CARD(1).EQ.PRINTB) GO TO 280
      IF (CARD(1).EQ.ENERGY) GO TO 340
      IF (CYCSW.NE.0) GO TO 24
      IF (NS.EQ.0) GO TO 30
24    IF (CARD(1).EQ.TIMEBS) GO TO 25
      IF (CARD(1).EQ.PLANEB) GO TO 25
      IF (CARD(1).EQ.CYLIND) GO TO 25
      IF (CARD(1).EQ.SPHERI) GO TO 25
      IF (CARD(1).EQ.RMINBB) GO TO 25
       IF(CARD(1).EQ.EOS) GO TO 25
      IF (CARD(1).EQ.REGION) GO TO 25
      IF (CARD(1).EQ.ZONEBB) GO TO 25
      IF (CARD(1).EQ.ZSOURC) GO TO 25
      IF (CARD(1).EQ.RSOURC) GO TO 25
      IF (CARD(1).EQ.BDRYBB) GO TO 25
      IF (CARD(1).EQ.COMBIN) GO TO 25
      IF (CARD(1).EQ.ZTEMPE) GO TO 25
      IF (CARD(1).EQ.PERCEN) GO TO 25
      IF (CARD(1).EQ.ENDATA) GO TO 25
       ERFLAG=1
      PRINT 1080
      PRINT 1,(CARD(I),I=1,10)
1080 FORMAT (1H0,30H CYCRED FRMT1080  ILLEGAL CARD /)
      READ (5,1) (CARD(I),I=1,10)
      WRITE (6,1) (CARD(I),I=1,10)
      GO TO 5
  25 RETURN
  30 WRITE (6,1000)
      WRITE (6,1)    (CARD(I),I=1,10)
1000 FORMAT (1H0,47H CYCRED FRMT1000 HISTORY,PRINT, OR ENERGY CHECK
    119H EDIT EXPECTED NOW. /)
      ERFLAG=1
      GO TO 24
  40 CYCSW=1
      II=1
       NDH(1)=0
  50 FIELDN=1
      WLAB=CARD(3)
  60 IF(WLAB.EQ.NDE.OR.WLAB.EQ.DTE) GO TO 140
  70 IF(WLAB.EQ.NCE.OR.WLAB.EQ.CTE) GO TO 200
  80 IF (WLAB.NE.BLANK) GO TO 110
      IF (II.LE.1) GO TO 120
  90 READ (5,1) (CARD(I),I=1,10)
      IF (CARD(1).EQ.BLANK) GO TO 100
      IF (CARD(1).NE.HISTOR) GO TO 5
      WRITE (6,1010)
      WRITE (6,1)    (CARD(I),I=1,10)
1010 FORMAT (1H0,44H CYCRED FRMT1010  MORE THAN ONE HISTORY EDIT ,
    16H CARD. /)
      GO TO 90
```

```
100  II=II+1
     GO TO 50
 110 ERFLAG=1
     WRITE (6,1020)
     WRITE (6,1)     (CARD(I),I=1,10)
1020 FORMAT (1H0,49H CYCRED FRMT1020  SECOND FIELD ON CARD IS NEITHER ,
    125H 'NC=', 'ND=', NOR BLANK. /)
     GO TO 90
 120 ERFLAG=1
     WRITE (6,1030)
     WRITE (6,1)     (CARD(I),I=1,10)
1030 FORMAT (1H0,46H CYCRED FRMT1030  THE FIRST FIELD OF THE FIRST ,
    122H CARD CANNOT BE BLANK. /)
     GO TO 90
 140 GO TO (150,180,150,180),FIELDN
 150 GO TO (160,290 ,350),CYCSW
 160 IF (WLAB.EQ.DTE.AND.FIELDN.EQ.1) DTH(II)=CARD(4)
     IF (WLAB.EQ.DTE.AND.FIELDN.EQ.3) DTH(II)=CARD(8)
     IF (WLAB.EQ.NDE.AND.FIELDN.EQ.1) NDH(II)= CARD(4)
     IF (WLAB.EQ.NDE.AND.FIELDN.EQ.3) NDH(II)= CARD(8)
 170 GO TO (175,180,177),FIELDN
 175 FIELDN=2
     WLAB=CARD(5)
     GO TO 60
 177  FIELDN=4
     WLAB=CARD(9)
      GO TO 60
 180 WRITE (6,1040)
     WRITE (6,1)     (CARD(I),I=1,10)
1040 FORMAT (1H0,47H CYCRED FRMT1040  'ND=' SHOULD BE IN EITHER THE ,
    126H FIRST OR THE THIRD FIELD. /)
     ERFLAG=1
     GO TO 90
 200 GO TO (210,220,210,220),FIELDN
 210 ERFLAG=1
     WRITE (6,1050)
     WRITE (6,1)     (CARD(I),I=1,10)
1050 FORMAT (1H0,47H CYCRED FRMT1050  'NC=' SHOULD BE IN EITHER THE ,
    128H SECOND OR THE FOURTH FIELD. /)
     GO TO 90
 220 GO TO (230,300,360),CYCSW
 230 IF (WLAB.EQ.NCE.AND.FIELDN.EQ.2) NHC(II)= CARD(6)
     IF (WLAB.EQ.NCE.AND.FIELDN.EQ.4) NHC(II)= CARD(10)
     IF (WLAB.EQ.CTE.AND.FIELDN.EQ.2) CTH(II)= CARD(6)
     IF (WLAB.EQ.CTE.AND.FIELDN.EQ.4) CTH(II)= CARD(10)
 240 GO TO (210,245,210,90),FIELDN
 245 II=II+1
     WLAB=CARD(7)
     FIELDN=3
     GO TO 60
```

```
 280 IF (CYCSW.EQ.2) GO TO 330
     CYCSW=2
     II=1
     NDP(1)=0
     GO TO 50
 290 IF (WLAB.EQ.NDE.AND.FIELDN.EQ.1) NDP(II)= CARD(4)
     IF (WLAB.EQ.NDE.AND.FIELDN.EQ.3) NDP(II)= CARD(8)
     IF (WLAB.EQ.DTE.AND.FIELDN.EQ.1)DTPR(II)= CARD(4)
     IF (WLAB.EQ.DTE.AND.FIELDN.EQ.3)DTPR(II)= CARD(8)
     GO TO 170
 300 IF (WLAB.EQ.NCE.AND.FIELDN.EQ.2) NPC(II)= CARD(6)
     IF (WLAB.EQ.NCE.AND.FIELDN.EQ.4) NPC(II)= CARD(10)
     IF (WLAB.EQ.CTE.AND.FIELDN.EQ.2) CTP(II)= CARD(6)
     IF (WLAB.EQ.CTE.AND.FIELDN.EQ.4) CTP(II)= CARD(10)
     GO TO 240
 330 ERFLAG=1
     WRITE (6,1060)
     WRITE (6,1)    (CARD(I),I=1,10)
1060 FORMAT (1H0,46H CYCRED FRMT1060  YOU HAVE MORE THAN ONE PRINT ,
    110H EDITCARD. /)
     READ (5,1) (CARD(I),I=1,10)
     GO TO 5
 340 IF (CYCSW.EQ.3) GO TO 390
     CYCSW=3
     II=1
     NDCK(1)=0
     GO TO 50
 350 IF (WLAB.EQ.DTE.AND.FIELDN.EQ.1)DTCK(II)= CARD(4)
     IF (WLAB.EQ.DTE.AND.FIELDN.EQ.3)DTCK(II)= CARD(8)
     IF (WLAB.EQ.NDE.AND.FIELDN.EQ.1)NDCK(II)= CARD(4)
     IF (WLAB.EQ.NDE.AND.FIELDN.EQ.3)NDCK(II)= CARD(8)
     GO TO 170
 360 IF (WLAB.EQ.NCE.AND.FIELDN.EQ.2)NCKC(II)= CARD(6)
     IF (WLAB.EQ.NCE.AND.FIELDN.EQ.4)NCKC(II)= CARD(10)
     IF (WLAB.EQ.CTE.AND.FIELDN.EQ.2)CTCK(II)= CARD(6)
     IF (WLAB.EQ.CTE.AND.FIELDN.EQ.4)CTCK(II)= CARD(10)
     GO TO 240
 390 ERFLAG=1
     WRITE (6,1070)
     WRITE (6,1)    (CARD(I),I=1,10)
1070 FORMAT (1H0,47H CYCRED FRMT1070  YOU HAVE MORE THAN ONE ENERGY
    117H CHECK EDIT CARD. /)
     GO TO 5
     END
```


START
CYCSW = 0
READ CARD (1)-(10)
A1
5
CARD(1): "HISTOR"
40
CYCSW = 1
II = 1
NDH(1) = 0
CARD(1): "PRINT"
280
CYCSW : 2
CYCSW = 2
II = 1
NDP(1)=0
330
ERFLAG = 1
WRITE MESSAGE
READ CARD (1)-(10)
A1
CARD(1): "ENERGY"
340
CYCSW : 3
CYCSW = 3
II = 1
NDCK(1)=0
390
ERFLAG = 1
WRITE MESSAGE
A1
CYCSW : 0
NS : 0
30
ERFLAG = 1
WRITE MESSAGE
24
IS CARD(1) A LEGIT LABEL ?
YES
NO
25
RET
ERFLAG = 1
PRINT CARD
READ CARD (1)-(10)
WRITE CARD
A1
50
FIELDN = 1
WLAB FROM CARD(3)
B1
60
WLAB "ND=" OR "DT="
A2
C1
70
WLAB "NC=" OR "CT="
B2
80
WLAB " "
110
ERFLAG = 1
WRITE MESSAGE
120
ERFLAG = 1
WRITE MESSAGE
II : 1
D1
90
READ CARD (1)-(10)
100
II = II + 1
CARD(1) : " "
A1
CARD(1): "HISTOR"
WRITE MESSAGE

CYCRED - 2


A2
140
FIELDN =
2,4
180
ERFLAG = 1
WRITE
MESSAGE
D1
1,3
150
CYCSW =
3
2
1
350
WLAB: "ND ="
CONVRT INTO NDCK (II)
WLAB: "DT ="
CONVRT INTO DTCK (II)
160
WLAB "DT ="
CONVRT INTO DTH (II)
WLAB: "ND ="
CONVRT INTO NDH (II)
290
WLAB: "ND ="
CONVRT INTO NDP (II)
WLAB: "DT ="
CONVRT INTO DTPR (II)
177
170
175
WLAB FROM CARD (9)
FIELDN = 4
FIELDN =
FIELDN = 2
WLAB FROM CARD (8)
B1
B1
B2
200
FIELDN =
1,3
210
ERFLAG = 1
WRITE
MESSAGE
D1
2,4
220
CYCSW
360
WLAB: "NC ="
CONVRT INTO NCKC (II)
WLAB "CT ="
CONVRT INTO CTCK (II)
230
WLAB: "NC ="
CONVRT INTO NHC (II)
WLAB: "CT ="
CONVRT INTO CTH (II)
300
WLAB: "NC ="
CONVRT INTO NPC (II)
WLAB: "CT ="
CONVRT INTO CTP (II)
240
245
D1
FIELDN =
II = II + 1
WLAB FROM CARD (7)
FIELDN = 3
B1

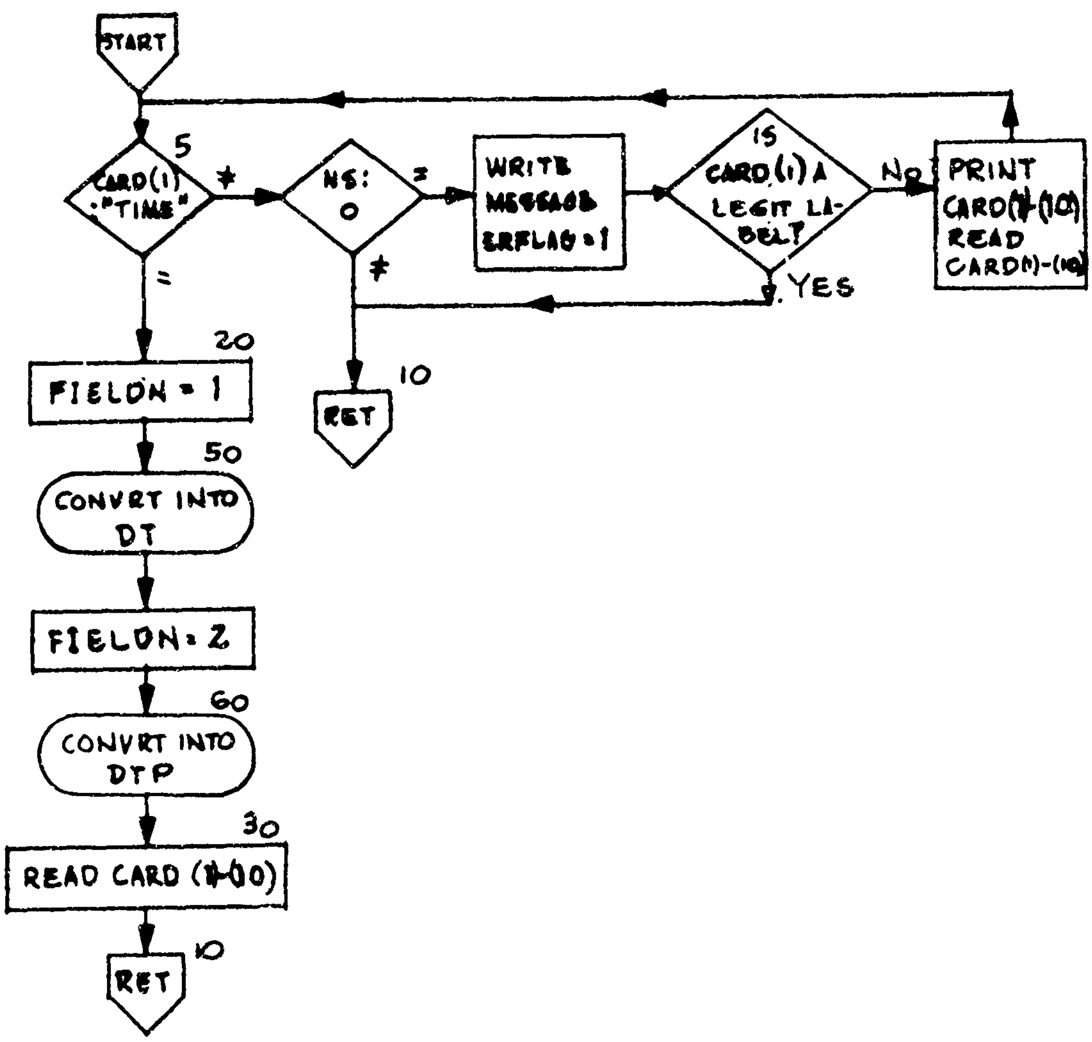
8. **THREAD**

THREAD reads and interprets the TIME STEP card.

```
$IBFTC THREAD  REF
      SUBROUTINE THREAD
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      COMMON /DQ/DTQ
      COMMON /BLNK/ BLANK
      COMMON /TEBS/ TIMEBS
      COMMON /UTSB/ UNITSB
      COMMON /PNEB/ PLANEB
      COMMON /CIND/CYLIND
      COMMON /SERI/SPHERI
      COMMON /RNBB/RMINBB
      COMMON /ESO/ EOS
      COMMON /RION/REGION
      COMMON /ZEBB/ ZONEBB
      COMMON /ZURC/ ZSOURC
      COMMON /RURC/ RSOURC
      COMMON /BYBB/ BDRYBB
      COMMON /CBIN/ COMBIN
      COMMON /ZMPE/ ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /EATA/ ENDATA
  5   IF (CARD(1).EQ.TIMEBS ) GO TO 20
      IF (NS.NE.0) GO TO 10
      WRITE (6,1000)
      WRITE (6,1)    (CARD(I),I=1,10)
 1000 FORMAT (1H0,48H THREAD FRMT1000   TIME STEP DEFINITION REQUIRED,
     111H WHEN NS=0. /)
      ERFLAG=1
      IF (CARD(1).EQ.PLANEB) GO TO 10
      IF (CARD(1).EQ.CYLIND) GO TO 10
      IF (CARD(1).EQ.SPHERI) GO TO 10
      IF (CARD(1).EQ.RMINBB) GO TO 10
      IF (CARD(1).EQ.EOS)    GO TO 10
      IF (CARD(1).EQ.REGION) GO TO 10
      IF (CARD(1).EQ.ZONEBB) GO TO 10
      IF (CARD(1).EQ.ZSOURC) GO TO 10
      IF (CARD(1).EQ.RSOURC) GO TO 10
      IF (CARD(1).EQ.BDRYBB) GO TO 10
      IF (CARD(1).EQ.COMBIN) GO TO 10
      IF (CARD(1).EQ.ZTEMPE) GO TO 10
      IF (CARD(1).EQ.PERCEN) GO TO 10
      IF (CARD(1).EQ.ENDATA) GO TO 10
       ERFLAG=1
      PRINT 1010
      PRINT 1,(CARD(I),I=1,10)
```

```
1010 FORMAT (1H0,31H TMREAD FRMT1010   ILLEGAL CARD  /)
     READ (5,1) (CARD(I),I=1,10)
   1  FORMAT (A6,F6.0,4(A3,E12.6))
     GO TO 5
  10 RETURN
  20 FIELDN=1
  50 DT=CARD(4)
     FIELDN=2
  60 DTP=CARD(6)
  30 READ (5,1) (CARD(I),I=1,10)
     GO TO 10
     END
```

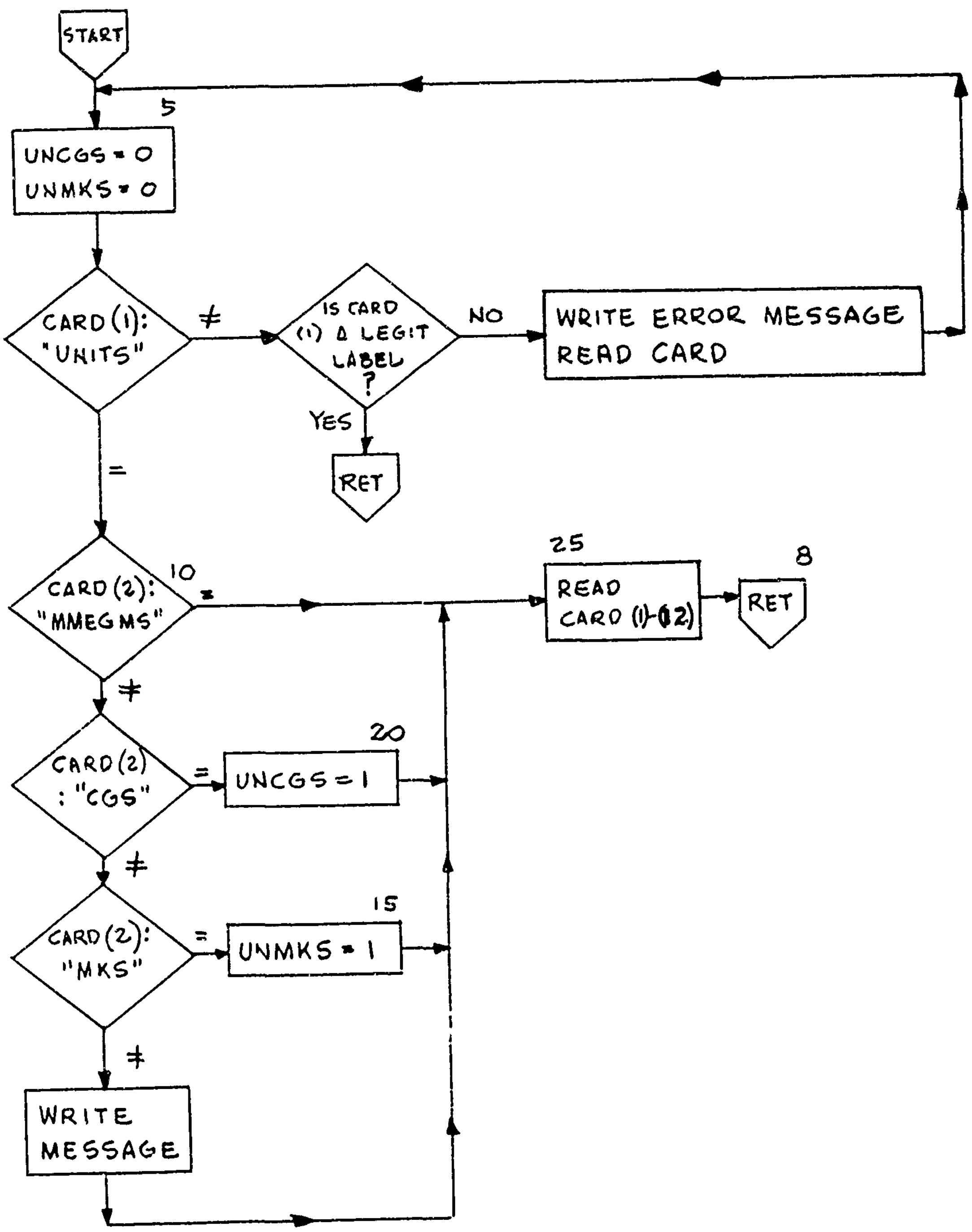
TMREAD



9. UNTRED (RAND version only)

UNTRED reads and interprets the UNITS card. It is designed to read MMEGMS, CGS or MKS units, but the MKS logic is not in the rest of the code yet. (Not a part of all-FORTRAN versions.)

UNTRED



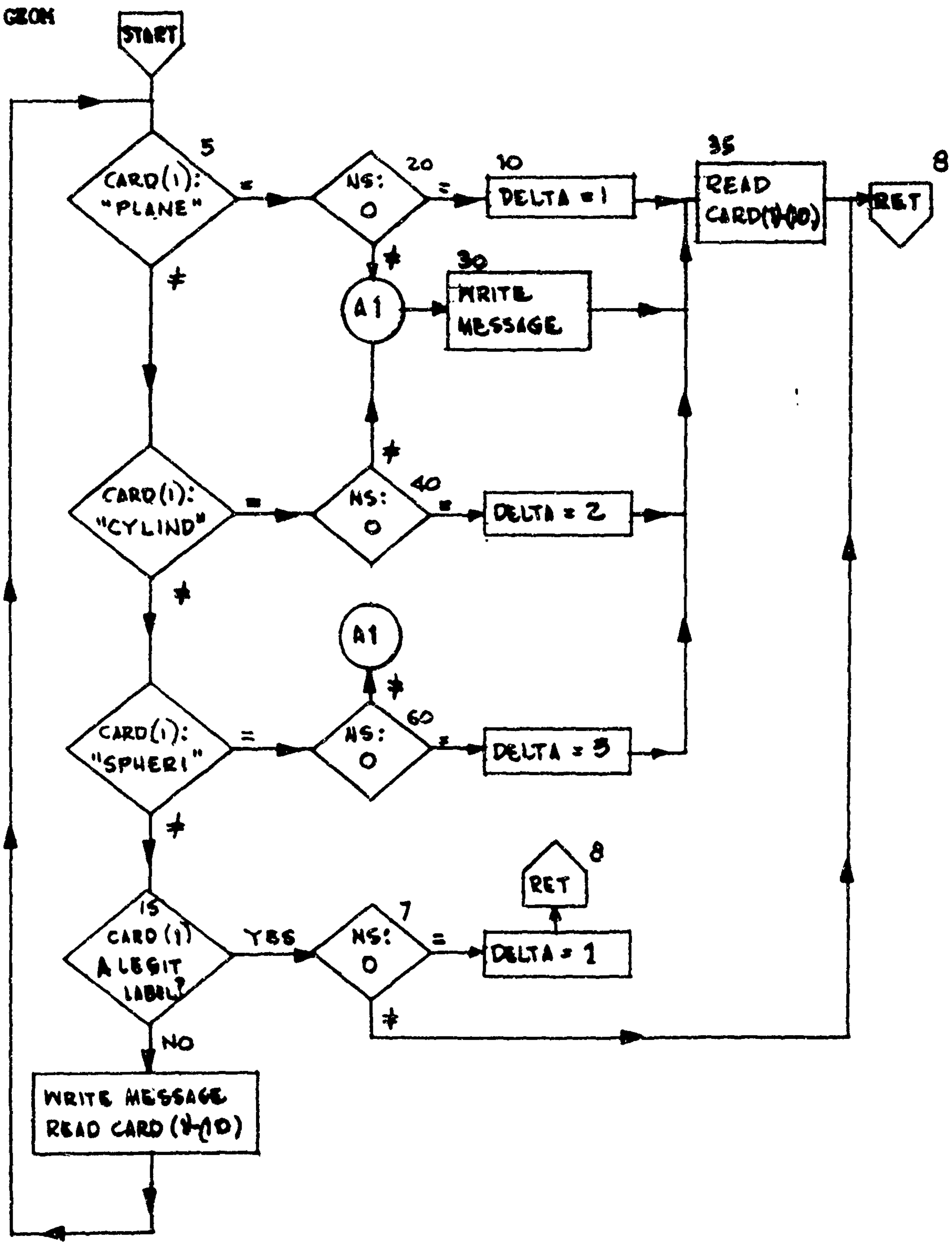
10. GEOM

GEOM reads and interprets the GEOMETRY card.

```
$IBFTC GEOM    REF
      SUBROUTINE GEOM
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      COMMON /PNEB/PLANEB
      COMMON /CIND/CYLIND
      COMMON /SERI/SPHERI
      COMMON/RNBB/RMINBB
      COMMON /ESO/ EOS
      COMMON/RION/REGION
      COMMON /ZEBB/ ZONEBB
      COMMON /ZURC/ ZSOURC
      COMMON /RURC/RSOURC
      COMMON /BYBB/BDRYBB
      COMMON /CBIN/COMBIN
      COMMON /ZMPE/ZTEMPE
      COMMON /PCEN/PERCEN
      COMMON /EATA/ENDATA
      INTEGER FIELDN,ERFLAG,CYCSW,UNCGS,UNMKS,DELTA
    1 FORMAT (A6,I6,4(A3,E12.6))
 5    IF (PLANEB.EQ.CARD(1) ) GO TO 20
      IF (CARD(1).EQ.CYLIND) GO TO 40
      IF (CARD(1).EQ.SPHERI )  GO TO 60
      IF (CARD(1).EQ.RMINBB) GO TO 7
       IF(CARD(1).EQ.EOS) GO TO 7
      IF (CARD(1).EQ.REGION) GO TO 7
      IF (CARD(1).EQ.ZONEBB) GO TO 7
      IF (CARD(1).EQ.ZSOURC) GO TO 7
      IF (CARD(1).EQ.RSOURC) GO TO 7
      IF (CARD(1).EQ.BDRYBB) GO TO 7
      IF (CARD(1).EQ.COMBIN) GO TO 7
      IF (CARD(1).EQ.ZTEMPE) GO TO 7
      IF (CARD(1).EQ.PERCEN) GO TO 7
      IF (CARD(1).EQ.ENDATA) GO TO 7
      ERFLAG=1
      WRITE (6,1010)
      WRITE (6,1)    (CARD(I),I=1,10)
 1010 FORMAT (1H0,38H GEOM FRMT1010    UNRECOGNIZABLE CARD. /)
      READ (5,1) (CARD(I),I=1,10)
      GO TO 5
 7    IF (NS.NE.0 ) GO TO 8
       DELTA=1
    8 RETURN
   10 DELTA=1
      GO TO 35
   20 IF (NS.EQ.0 ) GO TO 10
   30 ERFLAG=1
      WRITE (6,1000)
      WRITE (6,1)    (CARD(I),I=1,10)
 1000 FORMAT (1H0,50H GEOM FRMT1000    GEOMETRY CANNOT BE SPECIFIED FOR
```

```
  1,14H NONZERO CYCLE /)
35 READ (5,1) (CARD(I),I=1,10)
   GO TO 8
40 IF (NS.NE.0 ) GO TO 30
   DELTA=2
   GO TO 35
60 IF (NS.NE.0)  GO TO 30
   DELTA=3
   GO TO 35
   END
```

GEOM

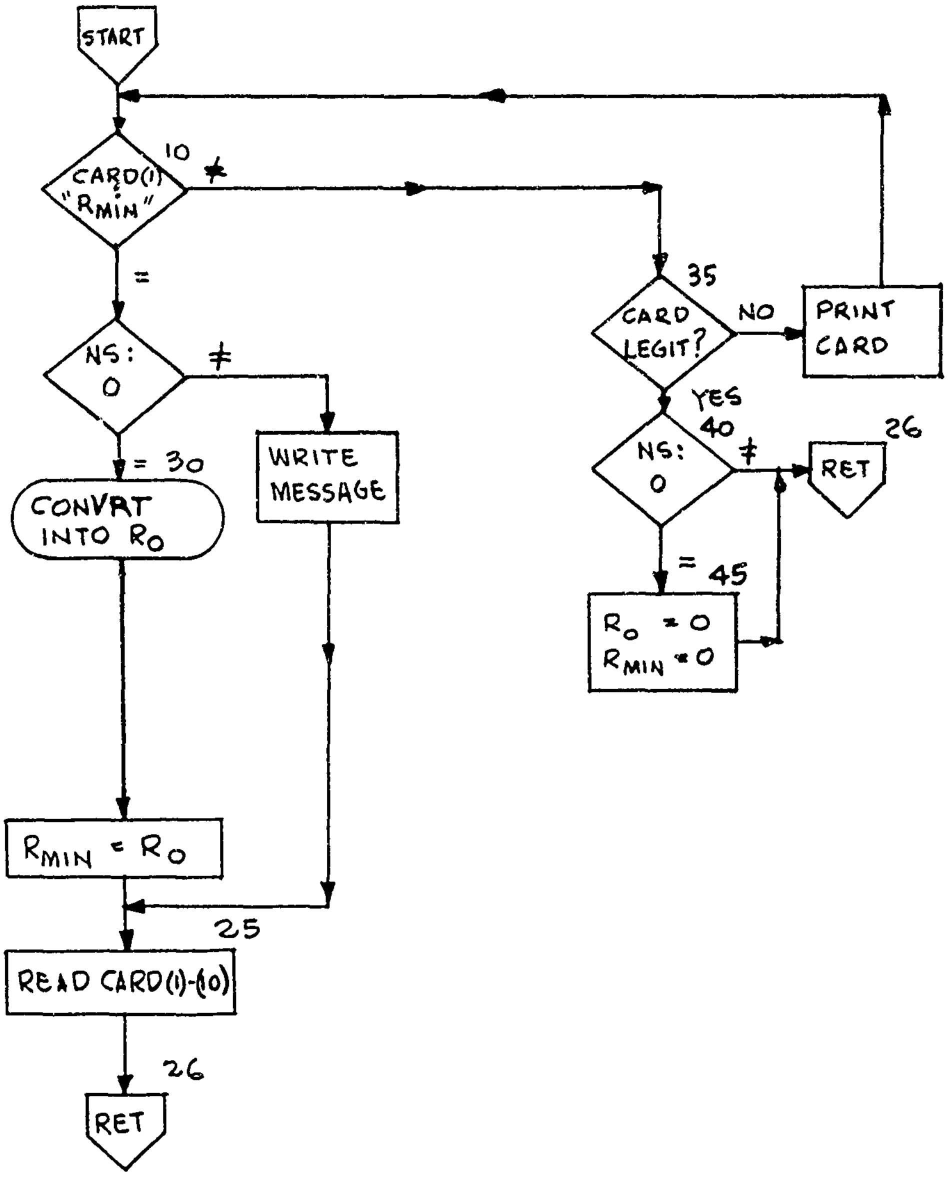


11. RMREAD

RMREAD reads and interprets the RMIN card, if any.

```
$IBFTC RMREAD  REF
      SUBROUTINE RMREAD
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
       COMMON /RC/ R(1)
      COMMON /RNBB/RMINBB
      COMMON /ESO/ EOS
      COMMON /RION/ REGION
      COMMON /ZEBB/ ZONEBB
      COMMON /ZURC/ ZSOURC
      COMMON /RURC/ RSOURC
      COMMON /BYBB/ BDRYBB
      COMMON /CBIN/ COMBIN
      COMMON /ZMPE/ ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /EATA/ ENDATA
    1 FORMAT (A6,F6.0,4(A3,E12.6))
   10 IF (CARD(1).NE.RMINBB ) GO TO 35
      IF (NS.EQ.0) GO TO 30
      ERFLAG=1
      WRITE (6,1000)
      WRITE (6,1)    (CARD(I),I=1,10)
 1000 FORMAT (1H0,51H RMREAD FRMT1000  RMIN SPECIFICATION WHEN NS NOT C.
     1 /)
   25 READ (5,1) (CARD(I),I=1,10)
   26 RETURN
   30 R(1)=CARD(4)
       RMIN=R(1)
      GO TO 25
   40 IF (NS.EQ.0 ) GO TO 45
      GO TO 26
   45 R(1)=0.
      RMIN=0.
      GO TO 26
   35  IF(CARD(1).EQ.EOS) GO TO 40
      IF (CARD(1).EQ.REGION) GO TO 40
      IF (CARD(1).EQ.ZONEBB) GO TO 40
      IF (CARD(1).EQ.ZSOURC) GO TO 40
      IF (CARD(1).EQ.RSOURC) GO TO 40
      IF (CARD(1).EQ.BDRYBB) GO TO 40
      IF (CARD(1).EQ.COMBIN) GO TO 40
      IF (CARD(1).EQ.ZTEMPE) GO TO 40
      IF (CARD(1).EQ.PERCEN) GO TO 40
      IF (CARD(1).EQ.ENDATA) GO TO 40
       ERFLAG=1
      WRITE (6,1010)
      WRITE (6,1) (CARD(I),I=1,10)
 1010 FORMAT (1H0,30H RMREAD FRMT1010  ILLEGAL CARD  /)
      READ (5,1) (CARD(I),I=1,10)
      GO TO 10
      END
```

RMREAD


START
10
CARD(1) : "RMIN"
≠
=
35
CARD LEGIT?
NO
PRINT CARD
YES
40
NS: 0
≠
26
RET
= 45
$R_o = 0$
$R_{MIN} = 0$
NS: 0
≠
WRITE MESSAGE
= 30
CONVRT INTO R_O
$R_{MIN} = R_O$
25
READ CARD(1)-(10)
26
RET

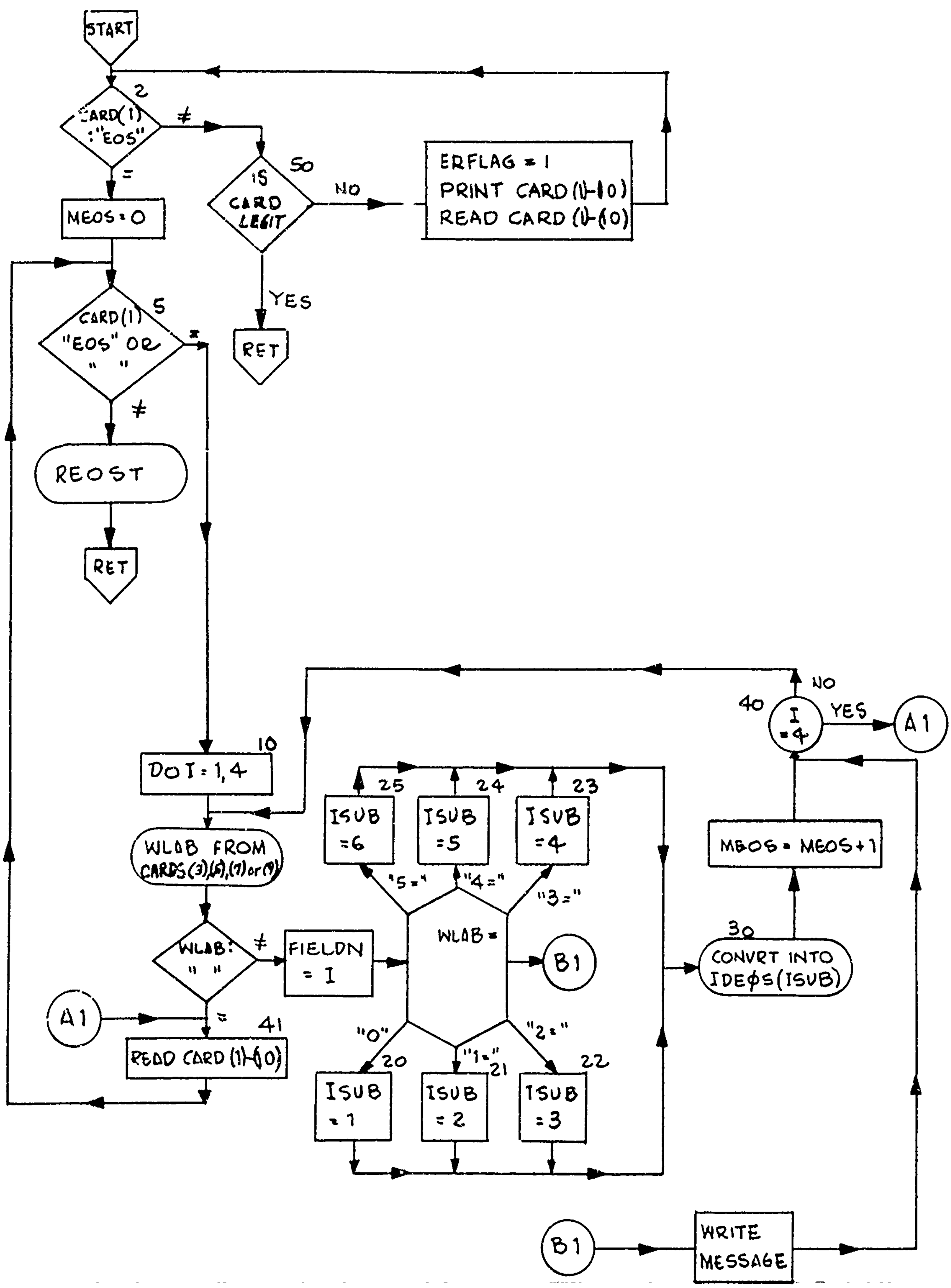
12. EOSNRD(C,LIMIT)

EOSNRD reads and interprets the EOS card. It transmits to REOST the information necessary for inputting the equation of state coefficients through the table IDEOS. $IDEOS_i$ contains the equation of state identification number for material number i+1. For example, let us say the first region of the problem was tabular aluminum and that this region was assigned material number 5. The identification number of aluminum is 513. Therefore IDEOS(6) = 513.

```
$IBFTC EOSNRD  REF
      SUBROUTINE EOSNRD(C,LIMIT)
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
       DIMENSION F(9), C(1)
      COMMON /ESO/ EOS,ZERO,ONE,TWO,THREE,FOUR,FIVE
      COMMON /RION/ REGION
      COMMON /ZEBB/ ZONEBB
      COMMON /ZURC/ ZSOURC
      COMMON /RURC/ RSOURC
      COMMON /BYBB/ BDRYBB
      COMMON /CBIN/ COMBIN
      COMMON /ZMPE/ ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /EATA/ ENDATA
      COMMON /BLNK/ BLANK
    2 IF(CARD(1).NE.EOS)  GO TO 50
       MEOS=0
    5 IF(CARD(1).EQ.EOS .OR.CARD(1).EQ.BLANK)  GO TO 10
      CALL REOST(C,LIMIT)
      RETURN
   10 DO 40 I=1,4
      IF (I.EQ.1) WLAB=CARD(3)
      IF (I.EQ.2) WLAB=CARD(5)
      IF (I.EQ.3) WLAB=CARD(7)
      IF (I.EQ.4) WLAB=CARD(9)
      IF(WLAB.EQ.BLANK)  GO TO 41
      FIELDN=I
      IF(WLAB.EQ.ZERO)  GO TO 20
      IF(WLAB.EQ.ONE)  GO TO 21
      IF(WLAB.EQ.TWO)  GO TO 22
      IF(WLAB.EQ.THREE)  GO TO 23
      IF(WLAB.EQ.FOUR)  GO TO 24
      IF(WLAB.EQ.FIVE)  GO TO 25
      WRITE (6,15) I
      WRITE (6,1) (CARD(NI),NI=1,10)
```

```
   15 FORMAT (1H0,47H EOSNRD FRMT15    THE  ,I1,  H TH FIELD ON THIS ,
     138H CARD CONTAINS AN UNACCEPTABLE NUMBER. /)
      GO TO 40
   20 ISUB=1
      GO TO 30
   21 ISUB =2
      GO TO 30
   22 ISUB = 3
      GO TO 30
   23 ISUB = 4
      GO TO 30
   24 ISUB =5
      GO TO 30
   25 ISUB =6
   30 IF (I.EQ.1) IDEOS(ISUB)=CARD(4 )
      IF (I.EQ.2) IDEOS(ISUB)=CARD(6 )
      IF (I.EQ.3) IDEOS(ISUB)=CARD(8 )
      IF (I.EQ.4) IDEOS(ISUB)=CARD(10)
       MEOS=MEOS+1
   40 CONTINUE
   41 READ (5,1) (CARD(I),I=1,10)
    1  FORMAT (A6,F6.0,4(A3,E12.6))
      GO TO 5
   50 IF (CARD(1).EQ.REGION) RETURN
      IF (CARD(1).EQ.ZONEBB) RETURN
      IF (CARD(1).EQ.ZSOURC) RETURN
      IF (CARD(1).EQ.RSOURC) RETURN
      IF (CARD(1).EQ.BDRYBB) RETURN
      IF (CARD(1).EQ.COMBIN) RETURN
      IF (CARD(1).EQ.ZTEMPE) RETURN
      IF (CARD(1).EQ.PERCEN) RETURN
      IF (CARD(1).EQ.ENDATA) RETURN
       ERFLAG=1
      WRITE (6,1000)
      WRITE (6,1) (CARD(I),I=1,10)
 1000 FORMAT (1H0,30H EOSNRD FRMT1000  ILLEGAL CARD /)
      READ (5,1) (CARD(I),I=1,10)
       GO TO 2
      END
```

EOSNRD


START
2
CARD(1) : "EOS"
≠
=
IS CARD LEGIT
50
NO
YES
RET
ERFLAG = 1
PRINT CARD (1)-(10)
READ CARD (1)-(10)
MEOS = 0
CARD(1) "EOS" OR " "
5
=
≠
REOST
RET
DO I = 1, 4
10
WLAB FROM CARDS (3),(5),(7) or (9)
WLAB : " "
≠
=
FIELDN = I
WLAB =
"5 ="
"4 ="
"3 ="
"0"
"1 ="
"2 ="
ISUB = 6
25
ISUB = 5
24
ISUB = 4
23
ISUB = 1
20
ISUB = 2
21
ISUB = 3
22
B1
A1
41
READ CARD (1)-(10)
30
CONVRT INTO IDEφS(ISUB)
MEOS = MEOS + 1
40
I = 4
NO
YES
A1
B1
WRITE MESSAGE

13. REOST(C,LIMIT)

REOST reads the interpolation coefficients from the equation of state tape prepared by TABCOE. The T's, ρ's and C's are stored in the C array as follows:

T's for P of 1st eq. of state encountered on the tape
ρ's for P of 1st eq. of state encountered on the tape
C's for P of 1st eq. of state encountered on the tape
T's for E of 1st eq. of state encountered on the tape
ρ's for E of 1st eq. of state encountered on the tape
C's for E of 1st eq. of state encountered on the tape
T's for K of 1st eq. of state encountered on the tape
ρ's for K of 1st eq. of state encountered on the tape
C's for K of 1st eq. of state encountered on the tape
T's for P of 2nd eq. of state encountered on the tape

.

.

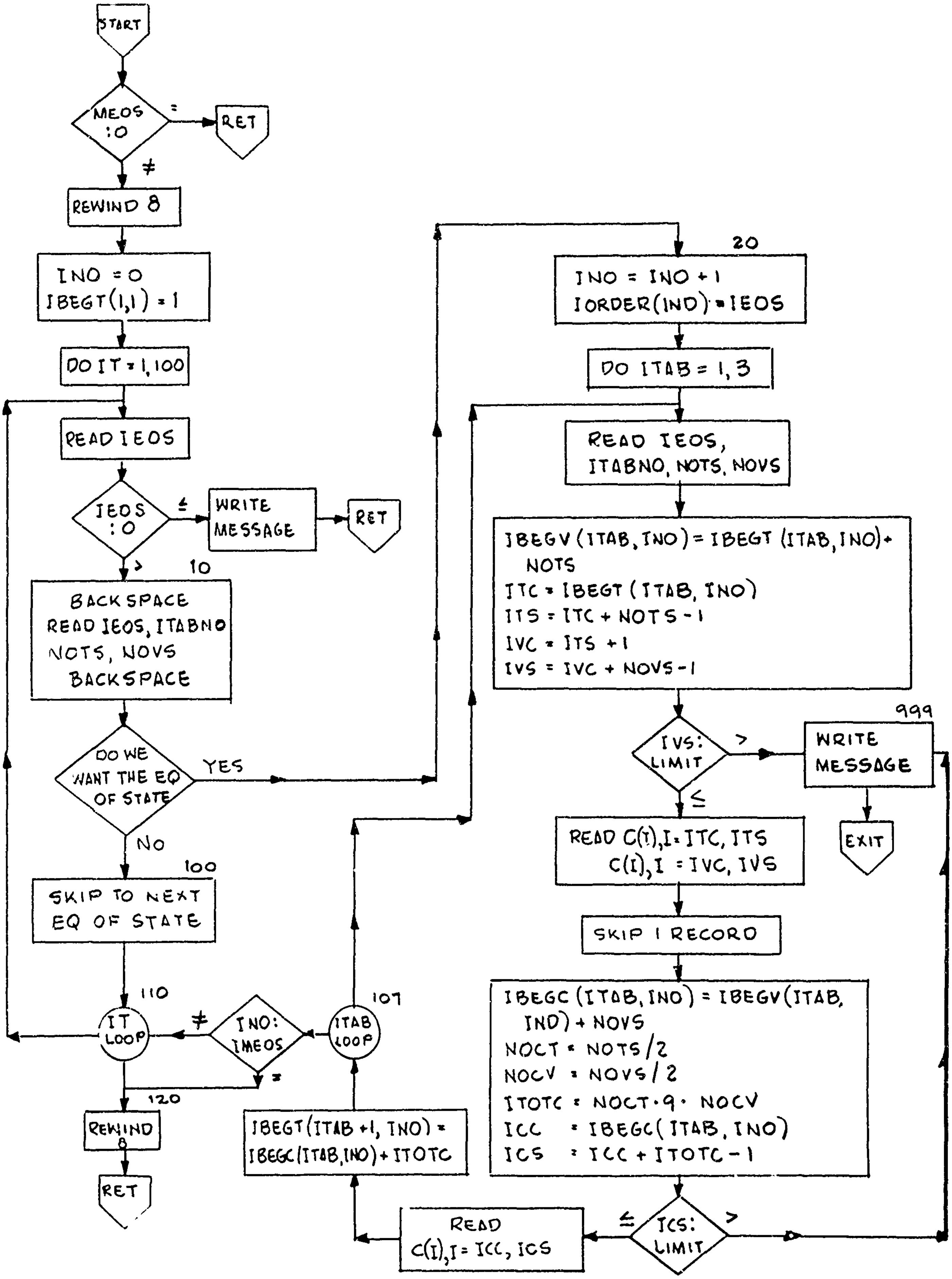
.

C's for K of last eq. of state encountered on the tape

Four tables are constructed for locating numbers in the C table. $IORDER_i$ contains the identification number of the ith equation of state read from the tape. IBEGT(i,j) contains the address of the first T of the ith equation of the jth equation of state. i = 1, 2 or 3 for P, E and K respectively. IBEGV(i,j) and IBEGC(i,j) are the first locations of the corresponding ρ and coefficient C.

```
$IBFTC REOST    REF
      SUBROUTINE REOST(C,LIMIT)
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
       DIMENSION F(9), C(1)
      IF(MEOS.EQ.0) RETURN
      REWIND 8
      INO=0
   15 IBEGT(1,1)=1
      DO 110 IT=1,100
      READ(8) IEOS
      IF(IEOS.GT.0 )  GO TO 10
      PRINT 7000,INO,MEOS
7000 FORMAT (56H1 REOST FRMT7000        END OF EOS TAPE ENCOUNTERED.  NO.
     124H OF EOS FOUND AND READ = I4,30H NO. OF EOS NEEDED IN THIS JOB
```

```
    2  2H = I4)
      RETURN
   10 BACKSPACE 8
      READ (8) IEOS,ITABNO,NOTS,NOVS
      BACKSPACE 8
      DO 18 I=1,6
      IF(IEOS.EQ.IDEOS(I))  GO TO 20
   18 CONTINUE
      GO TO 100
   20 INO=INO+1
      IORDER(INO)= IEOS
      DO 107 ITAB=1,3
      READ (8) IEOS,ITABNO,NOTS,NOVS
      IBEGV(ITAB,INO)=IBEGT(ITAB,INO)+NOTS
      ITC=IBEGT(ITAB,INO)
      ITS=ITC+NOTS-1
      IVC=ITS+1
      IVS=IVC+NOVS-1
       IF(IVS.GT.LIMIT) GO TO 999
      READ (8)             (C(I),I=ITC,ITS),(C(I),I=IVC,IVS)
C
C     SKIP NEXT RECORD ON EOS TAPE
C
      READ(8)
      IBEGC(ITAB,INO) =IBEGV(ITAB,INO)+NOVS
      NOCT=NOTS/2
      NOCV=NOVS/2
      ITOTC= NOCT*9*NOCV
      ICC = IBEGC(ITAB,INO)
      ICS=ICC+ITOTC-1
       IF(ICS.GT.LIMIT) GO TO 999
      READ (8) (C(I),I=ICC,ICS)
      IBEGT(ITAB+1,INO)= IBEGC(ITAB,INO)+ITOTC
  107 CONTINUE
      IF(INO.EQ.MEOS)  GO TO 120
      GO TO 110
C
C     SKIP NEXT 12 RECORDS - TO BEGINNING OF NEXT EOS INFORMATION
C
  100 DO 105 ISKIP =1,12
  105 READ (8)
  110 CONTINUE
  120 REWIND 8
      RETURN
  999 PRINT 7001
 7001 FORMAT (49H0 REQST FRMT7001      EOS TABLES REQUESTED EXCEED
    1 19H AVAILABLE STORAGE. )
       CALL EXIT
      END
```


START
MEOS :0
=
RET
≠
REWIND 8
INO = 0
IBEGT(1,1) = 1
DO IT = 1,100
READ IEOS
IEOS :0
≤
WRITE MESSAGE
RET
>
10
BACKSPACE
READ IEOS, ITABNO
NOTS, NOVS
BACKSPACE
DO WE WANT THE EQ OF STATE
YES
No
100
SKIP TO NEXT EQ OF STATE
110
IT LOOP
≠
INO: IMEOS
=
107
ITAB LOOP
120
REWIND 8
RET
IBEGT(ITAB +1, INO) = IBEGC(ITAB,INO) + ITOTC
20
INO = INO + 1
IORDER(IND) = IEOS
DO ITAB = 1, 3
READ IEOS, ITABNO, NOTS, NOVS
IBEGV (ITAB, INO) = IBEGT (ITAB, INO) + NOTS
ITC = IBEGT (ITAB, INO)
ITS = ITC + NOTS - 1
IVC = ITS + 1
IVS = IVC + NOVS - 1
IVS: LIMIT
>
999
WRITE MESSAGE
EXIT
≤
READ C(I), I = ITC, ITS
C(I), I = IVC, IVS
SKIP 1 RECORD
IBEGC (ITAB, INO) = IBEGV(ITAB, IND) + NOVS
NOCT = NOTS/2
NOCV = NOVS/2
ITOTC = NOCT·9· NOCV
ICC = IBEGC(ITAB, INO)
ICS = ICC + ITOTC - 1
ICS: LIMIT
≤
>
READ C(I), I = ICC, ICS

14. REGNRD

REGNRD reads and interprets the REGION and ZONE cards and calls subroutines to generate the zone variables.

```
$IBFTC REGNRD  REF
      SUBROUTINE REGNRD(C)
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HER
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
       COMMON /RC/ R(1)
      COMMON /TEMC/ TEM(1)
      COMMON /TAMC/ TAM(1)
      COMMON /VLC/ VL(1)
      COMMON /KPC/ KP(1)
      COMMON /KMC/ KM(1)
      COMMON /DMASSC/ DMASS(1)
      COMMON /DMESSC/ DMESS(1)
      COMMON /TEMSQC/ TEMSQ(1)
      COMMON /TEM3C/ TEM3(1)
      COMMON /TEM4C/ TEM4(1)
      COMMON /KDMC/ KDM(1)
      COMMON /ELC/ EL(1)
      COMMON /MATC/ MAT(1)
       COMMON /EGC/ EG(1)
      COMMON /RION/REGION
      COMMON /VQ/VEQ
      COMMON /JQ/JEQ
      COMMON /RQ/REQ
      COMMON /DRQ/DREQ
      COMMON /UQ/UEQ
      COMMON /TQ/TEQ
      COMMON /MQ/MEQ
      COMMON /RHQ/RHEQ
      COMMON /PQ/PEQ
      COMMON /EQ/EEQ
      COMMON /KQ/KEQ
      COMMON /C1Q/C1EQ
      COMMON /C2Q/C2EQ
      COMMON /C3Q/C3EQ
      COMMON /C4Q/C4EQ
      COMMON /C5Q/C5EQ
      COMMON /EOQ/FOEQ
      COMMON /BLNK/BLANK
      COMMON /ZEBB/ZONEBB
      REAL JEQ,KEQ,MEQ
       DIMENSION C(1)
    5 IF (CARD(1).EQ.REGION) GO TO 20
       IF(NS.EQ.0) GO TO 3
       IF(CARD(1).NE.ZONEBB) RETURN
       PRINT 7000
```

```
7000 FORMAT (1H0,45H REGNRD FRMT7000  ZONE CARD NOT PERMITTED FOR ,
    1 9H RESTART. /)
      READ (5,1) (CARD(I),I=1,10)
    1  FORMAT (A6,F6.0,4(A3,E12.6))
       GO TO 5
    3 IF (RGNSW.EQ.0) GO TO 10
      GO TO 360
   10 IF (NS.NE.0) GO TO 360
      ERFLAG=1
      WRITE (6,1000)
      WRITE (6,1) (CARD(I),I=1,10)
1000 FORMAT (1H0,49H REGNRD FRMT1000  MUST HAVE REGION CARD WHEN NS=0/)
      GO TO 360
   20 RGNSW=1
       ZNSWC=0
   30 REGNO=REGNO+1
      IF (REGNO.EQ.1) GO TO 32
      JORIG=JREG(REGNO-1)
      GO TO 35
32    JORIG=0
   35 IF (ZNSWC.EQ.0) GO TO 40
      NZONE=CARD(2)
38    TZWCH=0
      MZWCH=0
      VZWCH=0
      UZWCH=0
      RHZWCH=0
      PZWCH=0
      EZWCH=0
      KZWCH=0
      RSWCH=0
      DRSWCH=0
      GO TO 50
   40  IF(REGNO.EQ.1) GO TO 42
       IF(I2000.EQ.0) GO TO 42
       J1=JREG(REGNO-2)+2
       J2=JREG(REGNO-1)+1
       IF(REGNO.EQ.2) J1=2
       DO 41 I=J1,J2
       EL(I)=EG(I)
       EG(I)=TEM(I)
       TEM(I)=EL(I)
   41  EL(I)=0.
       I2000=0
   42 NEOS = CARD(2) + .1
       IF(NEOS.LT.2000) GO TO 43
       I2000=1
       NEOS=NEOS-1000
```

```
   43 JSWCH=0
      DRSWCH=0
      RSWCH=0
      TSWCH=0
      MSWCH=0
      VSWCH=0
      PSWCH=0
      ESWCH=0
      USWCH=0
      RHSWCH=0
      C1SWCH=0
      C2SWCH=0
      C3SWCH=0
      C4SWCH=0
      C5SWCH=0
      EOSWCH=0
      KSWCH=0
       IF(NS.NE.0) REGNO=NEOS
   50 WLAB=CARD(3)
      FIELDN=1
   55 IF (WLAB.NE.JEQ ) GO TO 70
      IF (JSWCH.EQ.0) GO TO 60
      ERFLAG=1
      WRITE (6,1020)
      WRITE (6,1) (CARD(I),I=1,10)
 1020 FORMAT (1H0,29H REGNRD FRMT1020  TWO JFIELDS /)
      GO TO 380
   60 JSWCH=1
      IF (ZNSWC.NE.0 ) GO TO 400
      IF (FIELDN.EQ.1) JREG(REGNO)=CARD( 4)
      IF (FIELDN.EQ.2) JREG(REGNO)=CARD( 6)
      IF (FIELDN.EQ.3) JREG(REGNO)=CARD( 8)
      IF (FIELDN.EQ.4) JREG(REGNO)=CARD(10)
      GO TO 390
   70 IF (WLAB.NE.REQ) GO TO 90
      IF (RSWCH.EQ.0) GO TO 80
      ERFLAG=1
      WRITE (6,1030)
      WRITE (6,1) (CARD(I),I=1,10)
 1030 FORMAT (1H0,44H REGNRD FRMT1030  THERE ARE TWO 'R=' FIELDS. /)
      GO TO 390
   80 RSWCH=1
      IF (ZNSWC.NE.0) GO TO 410
      IF (FIELDN.EQ.1)        RVAL=CARD( 4)
      IF (FIELDN.EQ.2)        RVAL=CARD( 6)
      IF (FIELDN.EQ.3)        RVAL=CARD( 8)
      IF (FIELDN.EQ.4)        RVAL=CARD(10)
      GO TO 390
   90 IF (WLAB.NE.DREQ) GO TO 110
      IF (DRSWCH.EQ.0) GO TO 100
      ERFLAG=1
      WRITE (6,1040)
      WRITE (6,1) (CARD(I),I=1,10)
```

```
1040 FORMAT (1H0,49H REGNRD FRMT1040  THERE ARE TWO DR FIELDS ON THIS ,
    1 6H CARD. /)
     GO TO 390
 100 DRSWCH=1
     IF (FIELDN.EQ.1)          DR=CARD( 4)
     IF (FIELDN.EQ.2)          DR=CARD( 6)
     IF (FIELDN.EQ.3)          DR=CARD( 8)
     IF (FIELDN.EQ.4)          DR=CARD(10)
     GO TO 390
 110 IF (WLAB.NE.UEQ) GO TO 130
     IF (ZNSWC.NE.0) GO TO 420
     IF (USWCH.EQ.0) GO TO 120
     ERFLAG=1
     WRITE (6,1050)
     WRITE (6,1) (CARD(I),I=1,10)
1050 FORMAT (1H0,48H REGNRD FRMT1050  TWO VELOCITY SPECIFICATIONS ON ,
    116H FOLLOWING CARD. /)
     GO TO 390
 120 USWCH=1
     IF (FIELDN.EQ.1)        UVAL=CARD( 4)
     IF (FIELDN.EQ.2)        UVAL=CARD( 6)
     IF (FIELDN.EQ.3)        UVAL=CARD( 8)
     IF (FIELDN.EQ.4)        UVAL=CARD(10)
     GO TO 390
 130 IF (WLAB.NE.TEQ) GO TO 150
     IF (ZNSWC.NE.0) GO TO 430
     IF (TSWCH.EQ.0) GO TO 140
     ERFLAG=1
     WRITE (6,1060)
     WRITE (6,1) (CARD(I),I=1,10)
1060 FORMAT (1H0,49H REGNRD FRMT1060  MORE THAN ONE TEMPERATURE FIELD/)
     GO TO 390
 140  IF(I2000.NE.0) GO TO 241
 141 TSWCH=1
     IF (FIELDN.EQ.1)        TVAL=CARD( 4)
     IF (FIELDN.EQ.2)        TVAL=CARD( 6)
     IF (FIELDN.EQ.3)        TVAL=CARD( 8)
     IF (FIELDN.EQ.4)        TVAL=CARD(10)
     GO TO 390
 150 IF (WLAB.NE.MEQ) GO TO 170
     IF (ZNSWC.NE.0) GO TO 450
     IF (MSWCH.NE.0) GO TO 160
     MSWCH=1
     IF (FIELDN.EQ.1)       DMVAL=CARD( 4)
     IF (FIELDN.EQ.2)       DMVAL=CARD( 6)
     IF (FIELDN.EQ.3)       DMVAL=CARD( 8)
     IF (FIELDN.EQ.4)       DMVAL=CARD(10)
     GO TO 390
 160 ERFLAG=1
     WRITE (6,1070)
     WRITE (6,1) (CARD(I),I=1,10)
```

```
1070 FORMAT (1H0,51H REGNRD FRMT1070  MORE THAN ONE MASS SPECIFICATION.
    1  /)
     GO TO 390
 170 IF (WLAB.NE.VEQ) GO TO 190
     IF (ZNSWC.NE.0) GO TO 470
     IF (VSWCH.EQ.0) GO TO 180
     ERFLAG=1
     WRITE (6,1080)
     WRITE (6,1) (CARD(I),I=1,10)
1080 FORMAT (1H0,48H REGNRD FRMT1080  MORE THAN ONE SPECIFIC VOLUME. /)
     GO TO 390
 180 VSWCH=1
     IF (FIELDN.EQ.1)        VVAL=CARD( 4)
     IF (FIELDN.EQ.2)        VVAL=CARD( 6)
     IF (FIELDN.EQ.3)        VVAL=CARD( 8)
     IF (FIELDN.EQ.4)        VVAL=CARD(10)
     GO TO 390
 190 IF (WLAB.NE.RHEQ) GO TO 210
     IF (ZNSWC.NE.0) GO TO 490
     IF (RHSWCH.EQ.0) GO TO 200
     ERFLAG=1
     WRITE (6,1090)
     WRITE (6,1) (CARD(I),I=1,10)
1090 FORMAT (1H0,39H REGNRD FRMT1090  MORE THAN ONE DENSITY
    1,15H SPECIFICATION. /)
     GO TO 390
 200 RHSWCH=1
     IF (FIELDN.EQ.1)       RHVAL=CARD( 4)
     IF (FIELDN.EQ.2)       RHVAL=CARD( 6)
     IF (FIELDN.EQ.3)       RHVAL=CARD( 8)
     IF (FIELDN.EQ.4)       RHVAL=CARD(10)
     GO TO 390
 210 IF (WLAB.NE.PEQ) GO TO 230
     IF (ZNSWC.NE.0) GO TO 510
     IF (PSWCH.EQ.0) GO TO 220
     ERFLAG=1
     WRITE (6,1100)
     WRITE (6,1) (CARD(I),I=1,10)
1100 FORMAT (1H0,40H REGNRD FRMT1100  MORE THAN ONE P FIELD. /)
     GO TO 390
 220 PSWCH=1
     IF (FIELDN.EQ.1)        PVAL=CARD( 4)
     IF (FIELDN.EQ.2)        PVAL=CARD( 6)
     IF (FIELDN.EQ.3)        PVAL=CARD( 8)
     IF (FIELDN.EQ.4)        PVAL=CARD(10)
     GO TO 390
 230 IF (WLAB.NE.EEQ) GO TO 250
     IF (ZNSWC.NE.0) GO TO 530
```

```
      IF (ESWCH.EQ.0) GO TU 240
      ERFLAG=1
      WRITE (6,1110)
      WRITE (6,1) (CARD(I),I=1,10)
 1110 FORMAT (1H0,45H REGNRD FRMT1110  MORE THAN ONE ENERGY FIELD. /)
      GO TO 390
  240  IF(I2000.NE.0) GO TO 141
  241 ESWCH=1
      IF (FIELDN.EQ.1)         EVAL=CARD( 4)
      IF (FIELDN.EQ.2)         EVAL=CARD( 6)
      IF (FIELDN.EQ.3)         EVAL=CARD( 8)
      IF (FIELDN.EQ.4)         EVAL=CARD(10)
      GO TO 390
  250 IF (WLAB.NE.KEQ) GO TO 270
      IF (ZNSWC.NE.0) GO TO 550
      IF (KSWCH.EQ.0) GO TO 260
      ERFLAG=1
      WRITE (6,1120)
      WRITE (6,1) (CARD(I),I=1,10)
 1120 FORMAT (1H0,40H REGNRD FRMT1120  MORE THAN ONE K FIELD. /)
      GO TO 390
  260 KSWCH=1
      IF (FIELDN.EQ.1)         KVAL=CARD( 4)
      IF (FIELDN.EQ.2)         KVAL=CARD( 6)
      IF (FIELDN.EQ.3)         KVAL=CARD( 8)
      IF (FIELDN.EQ.4)         KVAL=CARD(10)
      GO TO 390
  270 IF(WLAB.NE.C1EQ) GO TO 2900
      IF (C1SWCH.EQ.0) GO TO 280
      ERFLAG=1
      WRITE (6,1130)
      WRITE (6,1) (CARD(I),I=1,10)
 1130 FORMAT (1H0,41H REGNRD FRMT1130  MORE THAN ONE C1 FIELD. /)
      IF (ZNSWC.EQ.0) GO TO 390
  275 ERFLAG=1
      WRITE (6,1140)
      WRITE (6,1) (CARD(I),I=1,10)
 1140 FORMAT (1H0,44H REGNRD FRMT1140  A C1 FIELD ON A ZONE CARD. /)
      GO TO 390
  280 C1SWCH=1
      IF (ZNSWC.NE.0) GO TO 275
      IF (FIELDN.EQ.1)   C1(REGNO)=CARD( 4)
      IF (FIELDN.EQ.2)   C1(REGNO)=CARD( 6)
      IF (FIELDN.EQ.3)   C1(REGNO)=CARD( 8)
      IF (FIELDN.EQ.4)   C1(REGNO)=CARD(10)
      GO TO 390
 2900 IF(WLAB.NE.C2EQ) GO TO 290
      IF(C2SWCH.EQ.0) GO TO 3000
      ERFLAG=1
      WRITE (6,11500)
      WRITE (6,1) (CARD(I),I=1,10)
11500 FORMAT (1H0,41H REGNRD FRMT11500 MORE THAN ONE C2 FIELD. /)
      IF(ZNSWC.EQ.0) GO TO 390
 2950 ERFLAG=1
      WRITE (6,11600)
      WRITE (6,1) (CARD(I),I=1,10)
11600 FORMAT (1H0,49H REGNRD FRMT11600 C2 FIELD APPEARS ON A ZONE CARD/)
```

```
      GO TO 390
 3000 C2SWCH=1
      IF(ZNSWC.NE.0) GO TO 2950
      IF (FIELDN.EQ.1)   C2(REGNO)=CARD( 4)
      IF (FIELDN.EQ.2)   C2(REGNO)=CARD( 6)
      IF (FIELDN.EQ.3)   C2(REGNO)=CARD( 8)
      IF (FIELDN.EQ.4)   C2(REGNO)=CARD(10)
      GO TO 390
  290 IF (WLAB.NE.C3EQ) GO TO 310
      IF (C3SWCH.EQ.0) GO TO 300
      ERFLAG=1
      WRITE (6,1150)
      WRITE (6,1) (CARD(I),I=1,10)
 1150 FORMAT (1H0,41H REGNRD FRMT1150  MORE THAN ONE C3 FIELD. /)
      IF (ZNSWC.EQ.0) GO TO 390
  295 ERFLAG=1
      WRITE (6,1160)
      WRITE (6,1) (CARD(I),I=1,10)
 1160 FORMAT (1H0,49H REGNRD FRMT1160  C3 FIELD APPEARS ON A ZONE CARD/
      GO TO 390
  300 C3SWCH=1
      IF (ZNSWC.NE.0) GO TO 295
      IF (FIELDN.EQ.1)   C3(REGNO)=CARD( 4)
      IF (FIELDN.EQ.2)   C3(REGNO)=CARD( 6)
      IF (FIELDN.EQ.3)   C3(REGNO)=CARD( 8)
      IF (FIELDN.EQ.4)   C3(REGNO)=CARD(10)
      GO TO 390
  310 IF(WLAB.NE.C4EQ) GO TO 3300
      IF (C4SWCH.EQ.0) GO TO 320
      ERFLAG=1
      WRITE (6,1170)
      WRITE (6,1) (CARD(I),I=1,10)
 1170 FORMAT (1H0,41H REGNRD FRMT1170  MORE THAN ONE C4 FIELD. /)
      IF (ZNSWC.EQ.0) GO TO 390
  315 ERFLAG=1
      WRITE (6,1180)
      WRITE (6,1) (CARD(I),I=1,10)
 1180 FORMAT (1H0,49H REGNRD FRMT1180  C4 FIELD APPEARS ON A ZONE CARD/
      GO TO 390
  320 C4SWCH=1
      IF (ZNSWC.NE.0) GO TO 315
      IF (FIELDN.EQ.1)   C4(REGNO)=CARD( 4)
      IF (FIELDN.EQ.2)   C4(REGNO)=CARD( 6)
      IF (FIELDN.EQ.3)   C4(REGNO)=CARD( 8)
      IF (FIELDN.EG.4)   C4(REGNO)=CARD(10)
      GO TO 390
 3300 IF(WLAB.NE.C5EQ) GO TO 330
      IF(C5SWCH.EQ.0) GO TO 3400
      ERFLAG=1
      WRITE (6,11900)
      WRITE (6,1) (CARD(I),I=1,10)
11900 FORMAT (1H0,41HREGNRD FRMT11900  MORE THAN ONE C5 FIELD. /)
      IF(ZNSWC.EQ.0) GO TO 390
 3350 ERFLAG=1
      WRITE (6,12000)
      WRITE (6,1) (CARD(I),I=1,10)
12000 FORMAT (1H0,49H REGNRD FRMT12000 C5 FIELD APPEARS ON A ZONE CARD/)
```

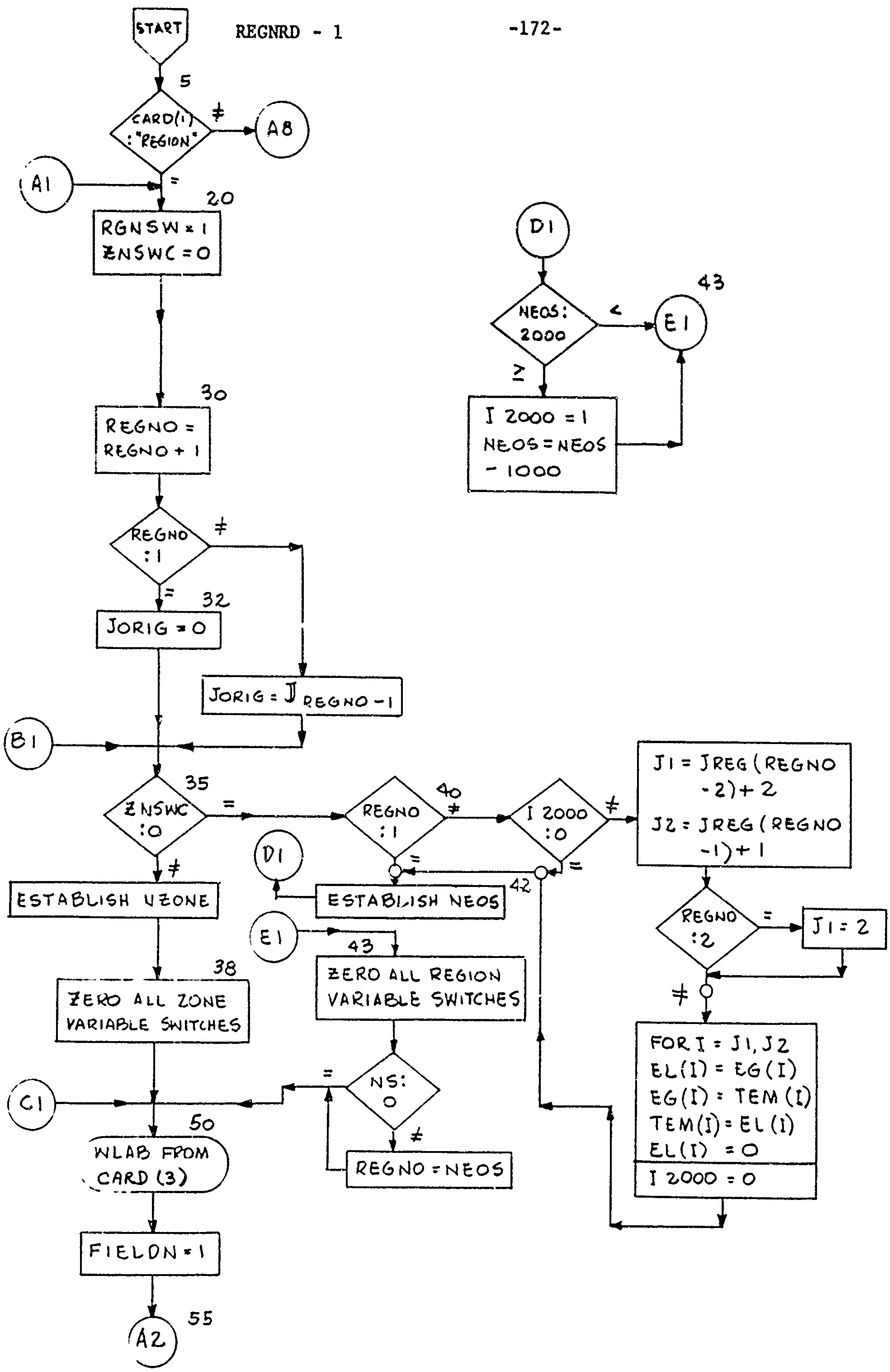
```
      GO TO 390
 3400 C5SWCH=1
      IF(ZNSWC.NE.0) GO TO 3350
      IF (FIELDN.EQ.1)   C5(REGNO)=CARD( 4)
      IF (FIELDN.EQ.2)   C5(REGNO)=CARD( 6)
      IF (FIELDN.EQ.3)   C5(REGNO)=CARD( 8)
      IF (FIELDN.EQ.4)   C5(REGNO)=CARD(10)
      GO TO 390
  330 IF (WLAB.NE.EOEQ) GO TO 350
      IF (EOSWCH.EQ.0) GO TO 340
      ERFLAG=1
      WRITE (6,1190)
      WRITE (6,1) (CARD(I),I=1,10)
 1190 FORMAT (1H0,42H REGNRD FRMT1190  MORE THAN ONE EO FIELD . /)
      IF (ZNSWC.EQ.0) GO TO 390
  335 ERFLAG=1
      WRITE (6,1200)
      WRITE (6,1) (CARD(I),I=1,10)
 1200 FORMAT (1H0,48H REGNRD FRMT1200  EO FIELD APPEARS ON ZONE CARD. /)
      GO TO 390
  340 EOSWCH=1
      IF (ZNSWC.NE.0) GO TO 335
      IF (FIELDN.EQ.1)   EO(REGNO)=CARD( 4)
      IF (FIELDN.EQ.2)   EO(REGNO)=CARD( 6)
      IF (FIELDN.EQ.3)   EO(REGNO)=CARD( 8)
      IF (FIELDN.EQ.4)   EO(REGNO)=CARD(10)
      GO TO 390
  350 IF (WLAB.EQ.BLANK) GO TO 570
      ERFLAG=1
      WRITE (6,1210)
      WRITE (6,1) (CARD(I),I=1,10)
 1210 FORMAT (1H0,49H REGNRD FRMT1210  ILLEGAL BCD LABEL ON THIS CARD./)
      GO TO 390
  360 ZNSWC=0
      IF (CARD(1).NE.ZONEBB) GO TO 590
      ZNSWC=1
  370 IF (RGNSW.NE.0) GO TO 35
      WRITE (6,1220)
      WRITE (6,1) (CARD(I),I=1,10)
 1220 FORMAT (1H0,46H REGNRD FRMT1220  THE FOLLOWING CARD SHOULD BE
     1,27H PRECEDED BY A REGION CARD. /)
      ERFLAG=1
      GO TO 35
  380 IF (ZNSWC.NE.0) GO TO 400
  390 GO TO (640,650,660,670),FIELDN
  400 ERFLAG=1
      WRITE (6,1230)
      WRITE (6,1) (CARD(I),I=1,10)
 1230 FORMAT (1H0,49H REGNRD FRMT1230  A J FIELD APPEARS ON ZONE CARD./)
      GO TO 390
  410 IF (FIELDN.EQ.1)         RVAL=CARD( 4)
      IF (FIELDN.EQ.2)         RVAL=CARD( 6)
      IF (FIELDN.EQ.3)         RVAL=CARD( 8)
      IF (FIELDN.EQ.4)         RVAL=CARD(10)
      GO TO 390
  420 IF (UZWCH.EQ.0) GO TO 425
      ERFLAG=1
```

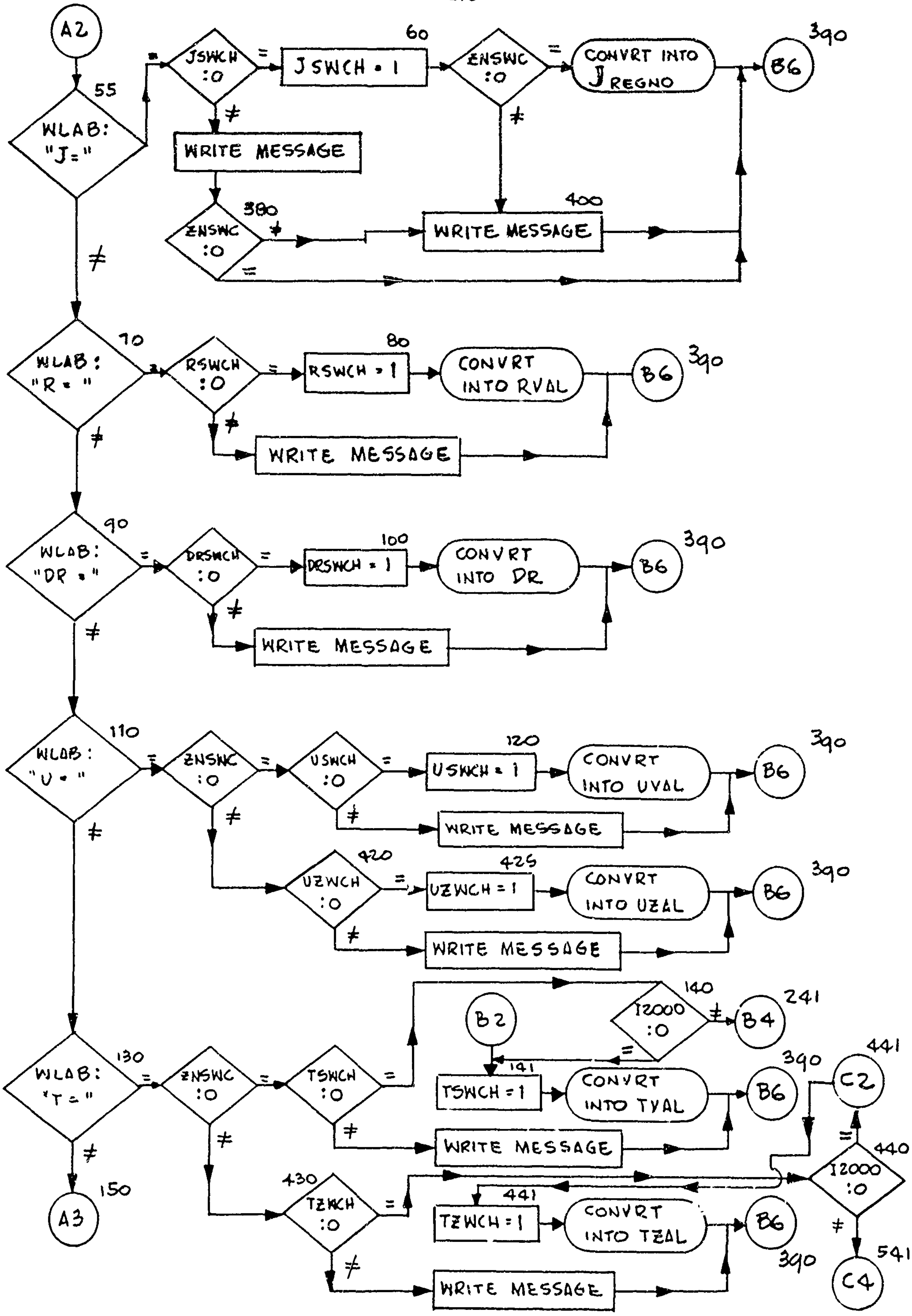
```
      WRITE (6,1240)
      WRITE (6,1) (CARD(I),I=1,10)
 1240 FORMAT (1H0,42H REGNRD FRMT1240  TWO U FIELDS FOR A ZONE. /)
      GO TO 390
 425  UZWCH=1
      IF (FIELDN.EQ.1)          UZAL=CARD( 4)
      IF (FIELDN.EQ.2)          UZAL=CARD( 6)
      IF (FIELDN.EQ.3)          UZAL=CARD( 8)
      IF (FIELDN.EQ.4)          UZAL=CARD(10)
      GO TO 390
  430 IF (TZWCH.EQ.0) GO TO 440
      ERFLAG=1
      WRITE (6,1250)
      WRITE (6,1) (CARD(I),I=1,10)
 1250 FORMAT (1H0,49H REGNRD FRMT1250  MORE THAN ONE T FIELD FOR ZONE./
      GO TO 390
  440  IF (I2000.NE.0) GO TO 541
  441 TZWCH=1
      IF (FIELDN.EQ.1)          TZAL=CARD( 4)
      IF (FIELDN.EQ.2)          TZAL=CARD( 6)
      IF (FIELDN.EQ.3)          TZAL=CARD( 8)
      IF (FIELDN.EQ.4)          TZAL=CARD(10)
      GO TO 390
  450 IF (MZWCH.EQ.0) GO TO 460
      ERFLAG=1
      WRITE (6,1260)
      WRITE (6,1) (CARD(I),I=1,10)
 1260 FORMAT (1H0,49H REGNRD FRMT1260  MORE THAN ONE M FIELD FOR ZONE./
      GO TO 390
  460 MZWCH=1
      IF (FIELDN.EQ.1)        DMZAL=CARD( 4)
      IF (FIELDN.EQ.2)        DMZAL=CARD( 6)
      IF (FIELDN.EQ.3)        DMZAL=CARD( 8)
      IF (FIELDN.EQ.4)        DMZAL=CARD(10)
      GO TO 390
  470 IF (VZWCH.EQ.0) GO TO 480
      ERFLAG=1
      WRITE (6,1270)
      WRITE (6,1) (CARD(I),I=1,10)
 1270 FORMAT (1H0,49H REGNRD FRMT1270  MORE THAN ONE V FIELD FOR ZONE./
      GO TO 390
  480 VZWCH=1
      IF (FIELDN.EQ.1)          VZAL=CARD( 4)
      IF (FIELDN.EQ.2)          VZAL=CARD( 6)
      IF (FIELDN.EQ.3)          VZAL=CARD( 8)
      IF (FIELDN.EQ.4)          VZAL=CARD(10)
      GO TO 390
  490 IF (RHZWCH.EQ.0) GO TO 500
      ERFLAG=1
      WRITE (6,1280)
      WRITE (6,1) (CARD(I),I=1,10)
 1280 FORMAT (1H0,49H REGNRD FRMT1280 MORE THAN ONE RH FIELD FOR ZONE./)
      GO TO 390
  500 RHZWCH=1
      IF (FIELDN.EQ.1)        RHZAL=CARD( 4)
      IF (FIELDN.EQ.2)        RHZAL=CARD( 6)
      IF (FIELDN.EQ.3)        RHZAL=CARD( 8)
```

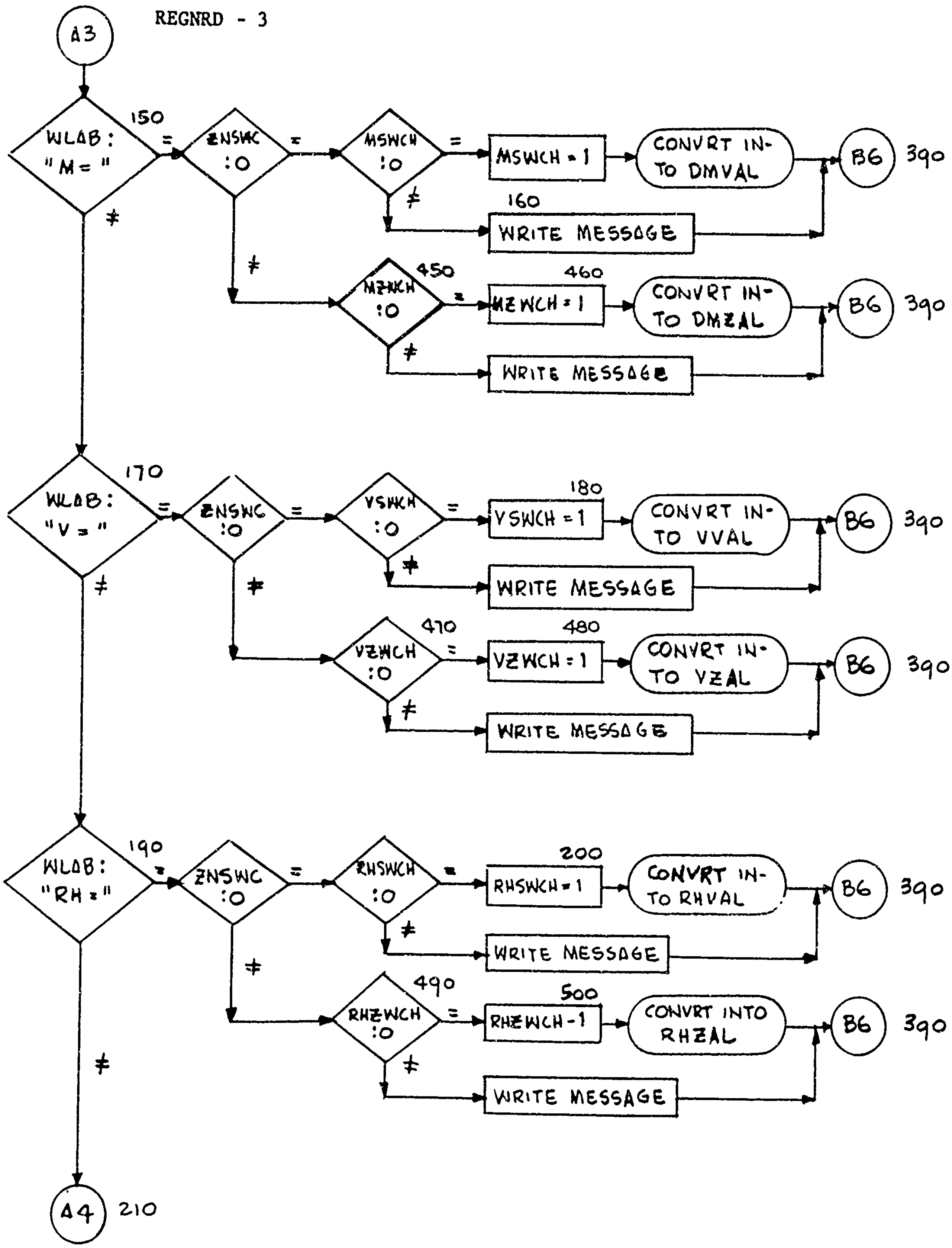
```
      IF (FIELDN.EQ.4)       RHZAL=CARD(10)
      GO TO 390
  510 IF (PZWCH.EQ.0) GO TO 520
      ERFLAG=1
      WRITE (6,1290)
      WRITE (6,1) (CARD(I),I=1,10)
 1290 FORMAT (1H0,49H REGNRD FRMT1290  MORE THAN ONE P FIELD FOR ZONE./)
      GO TO 390
  520 PZWCH=1
      IF (FIELDN.EQ.1)        PZAL=CARD( 4)
      IF (FIELDN.EQ.2)        PZAL=CARD( 6)
      IF (FIELDN.EQ.3)        PZAL=CARD( 8)
      IF (FIELDN.EQ.4)        PZAL=CARD(10)
      GO TO 390
  530 IF (EZWCH.EQ.0) GO TO 540
      ERFLAG=1
      WRITE (6,1300)
      WRITE (6,1) (CARD(I),I=1,10)
 1300 FORMAT (1H0,49H REGNRD FRMT1300  MORE THAN ONE E FIELD FOR ZONE./)
      GO TO 390
  540  IF (I2000.NE.0) GO TO 441
  541 EZWCH=1
      IF (FIELDN.EQ.1)        EZAL=CARD( 4)
      IF (FIELDN.EQ.2)        EZAL=CARD( 6)
      IF (FIELDN.EQ.3)        EZAL=CARD( 8)
      IF (FIELDN.EQ.4)        EZAL=CARD(10)
      GO TO 390
  550 IF (KZWCH.EQ.0) GO TO 560
      ERFLAG=1
      WRITE(6,1310)
      WRITE (6,1) (CARD(I),I=1,10)
 1310 FORMAT (1H0,49H REGNRD FRMT1310  MORE THAN ONE K FIELD FOR ZONE./)
      GO TO 390
  560 KZWCH=1
      IF (FIELDN.EQ.1)        KZAL=CARD( 4)
      IF (FIELDN.EQ.2)        KZAL=CARD( 6)
      IF (FIELDN.EQ.3)        KZAL=CARD( 8)
      IF (FIELDN.EQ.4)        KZAL=CARD(10)
      GO TO 390
  570 READ (5,1) (CARD(I),I=1,10)
       IF(NS.NE.0) GO TO 5
      IF (ZNSWC.NE.0) GO TO 580
 575  CALL GRIDGN
      CALL ZONGEN(C)
      GO TO 5
  580 CALL ZNGET
      CALL ZONGEN(C)
      GO TO 620
  590 IF (ZGETSW.NE.0) GO TO 600
      IF (CARD(1).EQ.REGION) GO TO 20
       IF (I2000.EQ.0) GO TO 593
       J1 = JREG(REGNO-1)+2
       J2 = JREG(REGNO) + 1
       IF (REGNO.EQ.1) J1= 2
       DO 591 I=J1,J2
       EL(I) = EG(I)
       EG(I) = TEM(I)
```

```
      TEM(I) = EL(I)
  591  EL(I) = 0.
  593 NREG=REGNO
      JMAX=JREG(NREG)
       IF (IHYD.NE.0) GO TO 594
      IF(REGNO.EQ.1) GO TO 594
      REGNO=1
  592 JZ=JREG(REGNO)
      TAM(JZ+1)= ( .5*(TEM(JZ+2)**4+TEM(JZ+1)**4 ) )**.25
      CALL PEK (3,MAT(JZ+1),TAM(JZ+1),VL(JZ+1),JZ,0,KM(JZ+1),C)
      CALL PEK (3,MAT(JZ+2),TAM(JZ+1),VL(JZ+2),JZ,0,KP(JZ+1),C)
      IF (REGNO.GE.NREG-1) GO TO 594
      REGNO=REGNO+1
      GO TO 592
  594 JZ=0
      GO TO 596
  595 DMESS(JZ+1)=0.5*(DMASS(JZ+1)+DMASS(JZ+2) )
  596  IF (IHYD.NE.0) GO TO 597
      TEMSQ(JZ+2)=TEM(JZ+2)**2
      TEM3(JZ+2)=  TEM(JZ+2)*TEMSQ(JZ+2)
      TEM4(JZ+2)=  TEM(JZ+2)*TEM3(JZ+2)
      IF (JZ.EQ.0) GO TO 597
      KDM(JZ+1)=0.5*(DMASS(JZ+1)*KM(JZ+1)+DMASS(JZ+2)*KP(JZ+1) )
      EL(JZ+1)=R(JZ+1)**(2*(DELTA-1))*(TEM4(JZ+1)-TEM4(JZ+2))/KDM(JZ+
  597 IF (JZ.GE.JMAX-1) GO TO 598
      JZ=JZ+1
      GO TO 595
  598 RETURN
  600 IF (JREG(REGNO-1).LT.JREG(REGNO) ) GO TO 610
      ERFLAG=1
      WRITE (6,1320)
      WRITE (6,1) (CARD(I),I=1,10)
 1320 FORMAT (1H0,44H REGNRD FRMT1320  SHOULD HAVE A ZONE CARD TO
     1,26H COMPLETE GRID DEFINITION. /)
  610 ZGETSW=0
      GO TO 590
  620 IF (ZGETSW.EQ.0) GO TO 630
      JREG(REGNO)=JORIG+NZONE
 622  IF (JORIG.LE.0) GO TO 625
       IF(IHYD.NE.0) GO TO 625
      TAM(JORIG+1)=(.5*(TEM(JORIG+2)**4+TEM(JORIG+1)**4))**.25
      CALL PEK (3,MAT(JORIG+1),TAM(JORIG+1),VL(JORIG+1),JORIG,0,
     1  KM(JORIG+1),C)
      CALL PEK (3,MAT(JORIG+2),TAM(JORIG+1),VL(JORIG+2),JORIG,0,
     1  KP(JORIG+1),C)
  625 JORIG=JORIG+NZONE
      GO TO 360
 630  IF (JORIG.LT.JREG(REGNO)-NZONE) GO TO 622
      GO TO 610
  640 FIELDN=2
      WLAB=CARD(5)
      GO TO 55
  650 FIELDN=3
      WLAB=CARD(7)
      GO TO 55
  660 FIELDN=4
      WLAB=CARD(9)
```

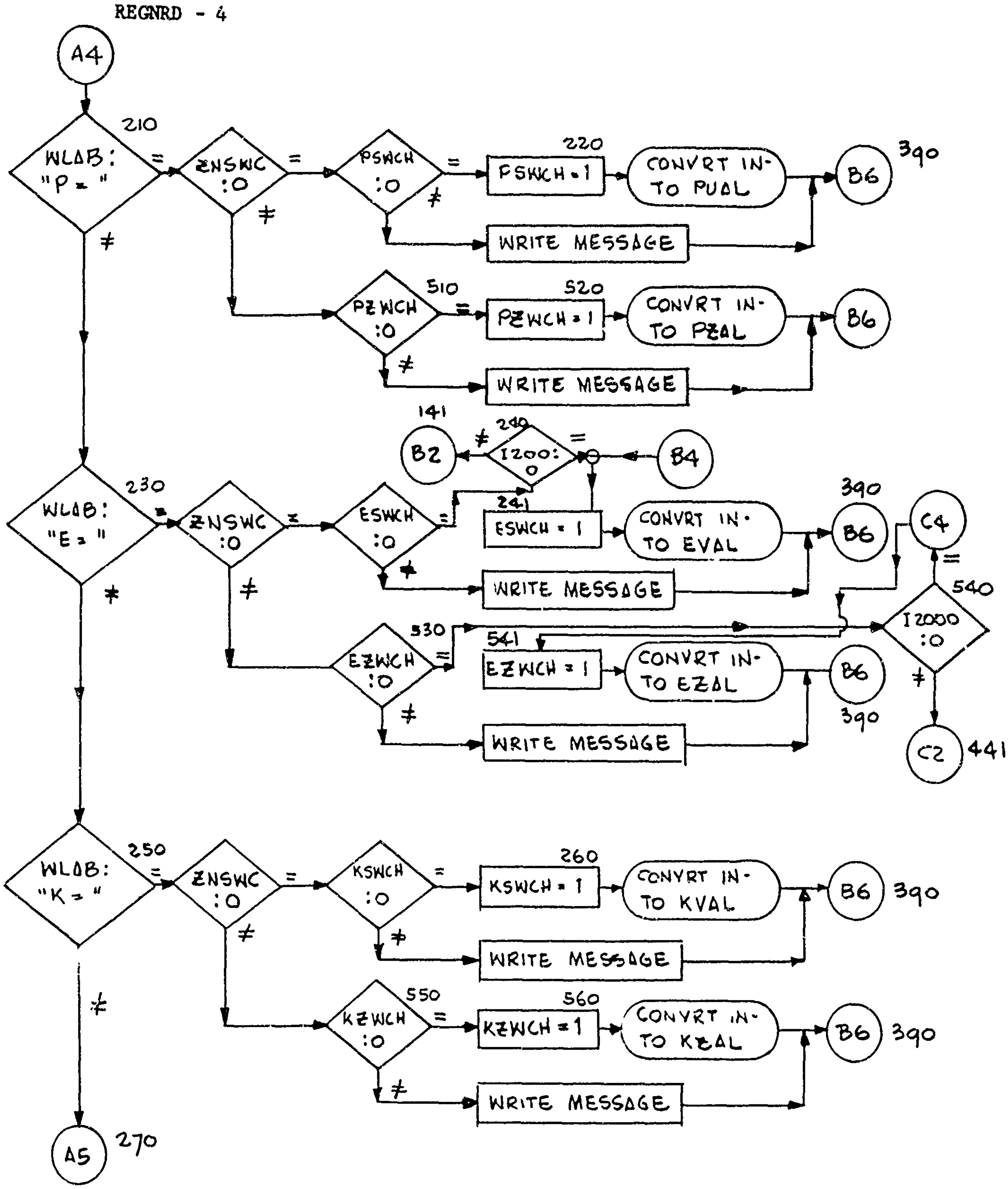
```
      GO TO 55
  670 READ (5,1) (CARD(I),I=1,10)
      IF (CARD(1).EQ.BLANK) GO TO 680
      IF (ZNSWC.EQ.0) GO TO 575
      GO TO 580
  680 IF (ZNSWC.EQ.0) GO TO 50
      ERFLAG=1
      WRITE (6,1330)
      WRITE (6,1) (CARD(I),I=1,10)
 1330 FORMAT (1H0,45H REGNRD FRMT1330  ZONE CARD SHOULD NOT HAVE A
     1,14H CONTINUATION. /)
      GO TO 370
      END
```


START
5
CARD(1) : "REGION"
≠
=
A8
A1
20
RGNSW = 1
ZNSWC = 0
30
REGNO = REGNO + 1
REGNO :1
32
JORIG = 0
JORIG = J REGNO-1
B1
35
ZNSWC :0
ESTABLISH UZONE
38
ZERO ALL ZONE VARIABLE SWITCHES
C1
50
WLAB FROM CARD (3)
FIELDN = 1
55
A2
40
REGNO :1
D1
ESTABLISH NEOS
42
E1
43
ZERO ALL REGION VARIABLE SWITCHES
NS: 0
REGNO = NEOS
I 2000 :0
J1 = JREG(REGNO -2)+2
J2 = JREG(REGNO -1)+1
REGNO :2
J1 = 2
FOR I = J1, J2
EL(I) = EG(I)
EG(I) = TEM(I)
TEM(I) = EL(I)
EL(I) = 0
I 2000 = 0
NEOS: 2000
<
≥
I 2000 = 1
NEOS = NEOS - 1000

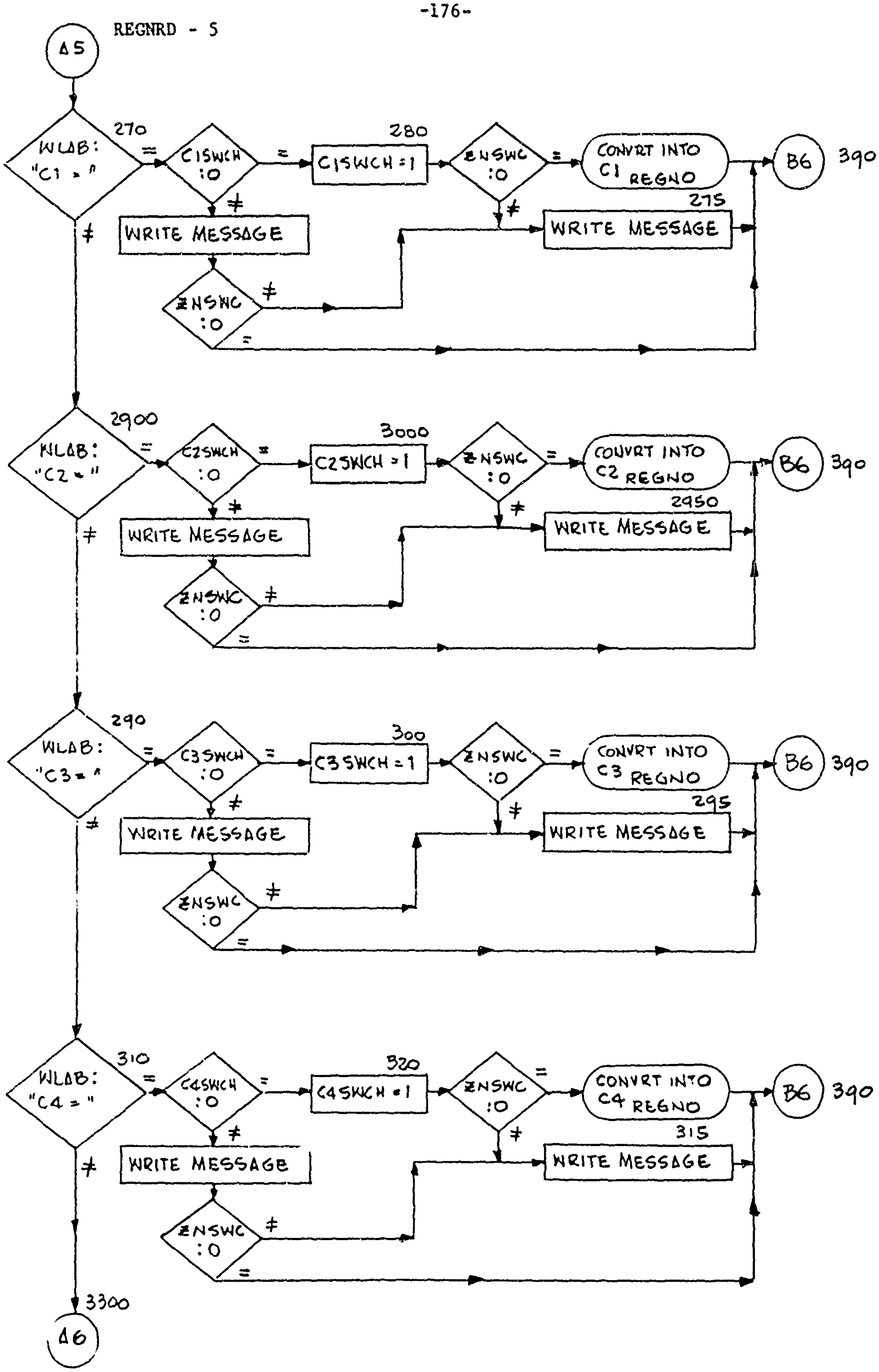

A2
55
WLAB: "J="
JSWCH :0
60
JSWCH = 1
ZNSWC :0
CONVRT INTO J REGNO
B6
390
WRITE MESSAGE
380
ZNSWC :0
400
WRITE MESSAGE
70
WLAB: "R ="
RSWCH :0
80
RSWCH = 1
CONVRT INTO RVAL
B6
390
WRITE MESSAGE
90
WLAB: "DR ="
DRSWCH :0
100
DRSWCH = 1
CONVRT INTO DR
B6
390
WRITE MESSAGE
110
WLAB: "U ="
ZNSWC :0
USWCH :0
120
USWCH = 1
CONVRT INTO UVAL
B6
390
WRITE MESSAGE
420
UZWCH :0
425
UZWCH = 1
CONVRT INTO UZAL
B6
390
WRITE MESSAGE
130
WLAB: "T ="
ZNSWC :0
TSWCH :0
140
I2000 :0
B4
241
B2
141
TSWCH = 1
CONVRT INTO TVAL
B6
390
C2
441
WRITE MESSAGE
440
I2000 :0
430
TZWCH :0
441
TZWCH = 1
CONVRT INTO TZAL
B6
390
WRITE MESSAGE
C4
541
A3
150

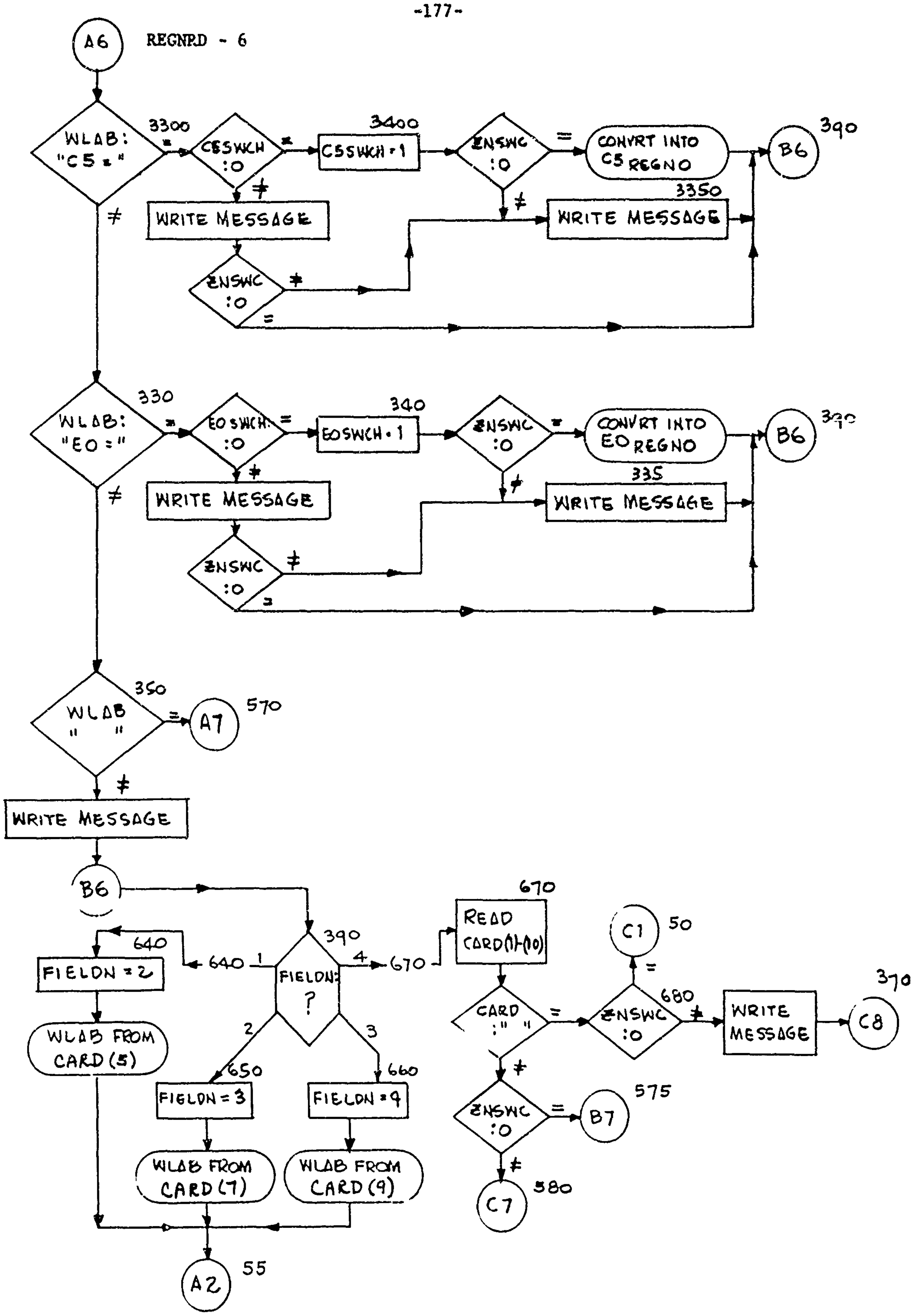

A3
REGNRD - 3
WLAB: "M="
150
ZNSWC :0
MSWCH :0
MSWCH = 1
CONVRT INTO DMVAL
B6 390
160
WRITE MESSAGE
MZWCH :0
450
460
MZWCH = 1
CONVRT INTO DMZAL
B6 390
WRITE MESSAGE
WLAB: "V ="
170
ZNSWC :0
VSWCH :0
180
VSWCH = 1
CONVRT INTO VVAL
B6 390
WRITE MESSAGE
VZWCH :0
470
480
VZWCH = 1
CONVRT INTO VZAL
B6 390
WRITE MESSAGE
WLAB: "RH ="
190
ZNSWC :0
RHSWCH :0
200
RHSWCH = 1
CONVRT INTO RHVAL
B6 390
WRITE MESSAGE
RHZWCH :0
490
500
RHZWCH - 1
CONVRT INTO RHZAL
B6 390
WRITE MESSAGE
A4 210

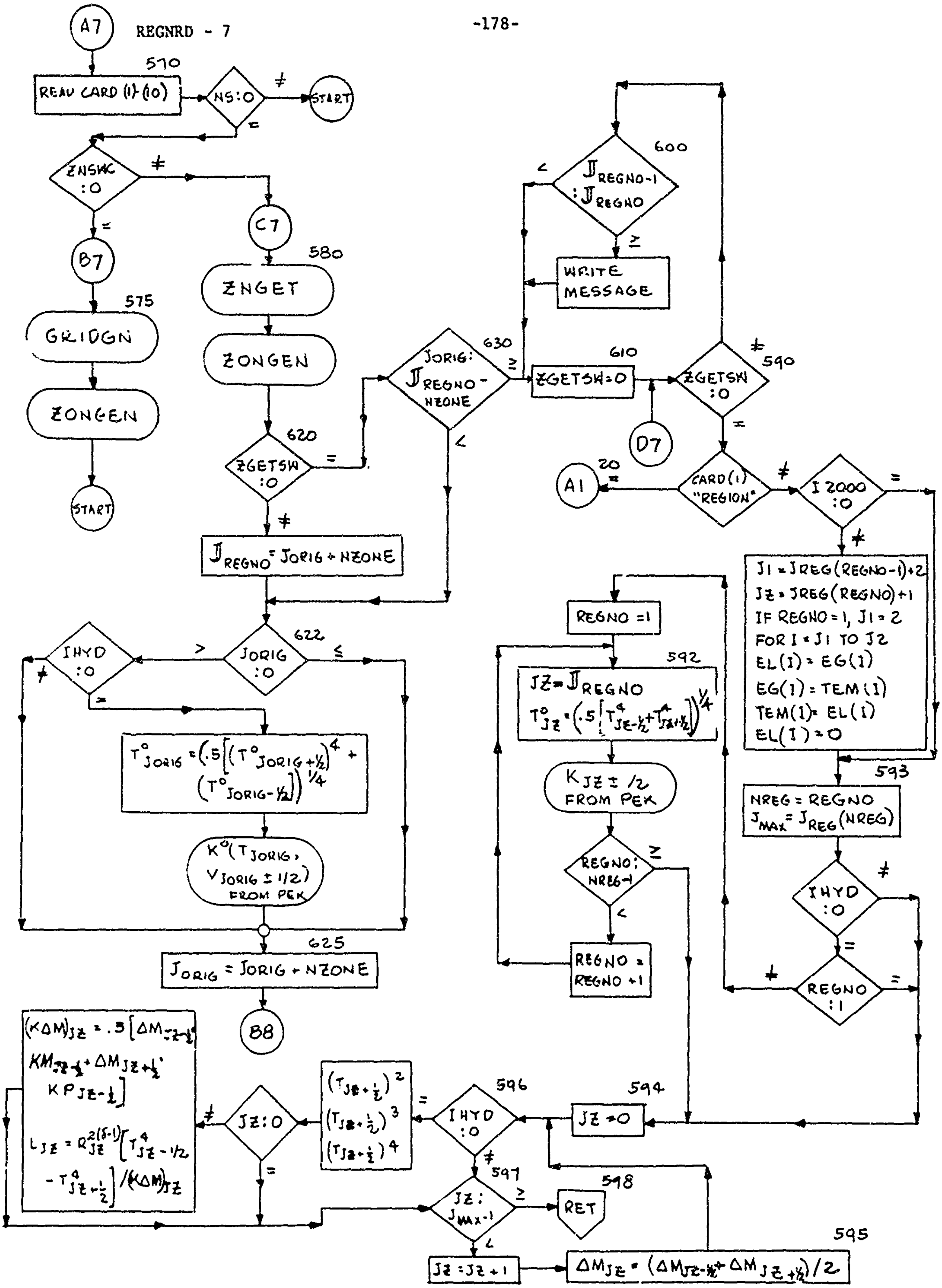
REGNRD - 4


A4
210
WLAB: "P ="
ZNSWC :0
PSWCH :0
220
PSWCH = 1
CONVRT INTO PVAL
B6
390
WRITE MESSAGE
510
PZWCH :0
520
PZWCH = 1
CONVRT INTO PZAL
B6
WRITE MESSAGE
141
B2
240
I200: 0
B4
230
WLAB: "E ="
ZNSWC :0
ESWCH :0
241
ESWCH = 1
CONVRT INTO EVAL
390
B6
C4
WRITE MESSAGE
540
I2000 :0
530
EZWCH :0
541
EZWCH = 1
CONVRT INTO EZAL
B6
390
WRITE MESSAGE
C2
441
250
WLAB: "K ="
ZNSWC :0
KSWCH :0
260
KSWCH = 1
CONVRT INTO KVAL
B6
390
WRITE MESSAGE
550
KZWCH :0
560
KZWCH = 1
CONVRT INTO KZAL
B6
390
WRITE MESSAGE
A5
270

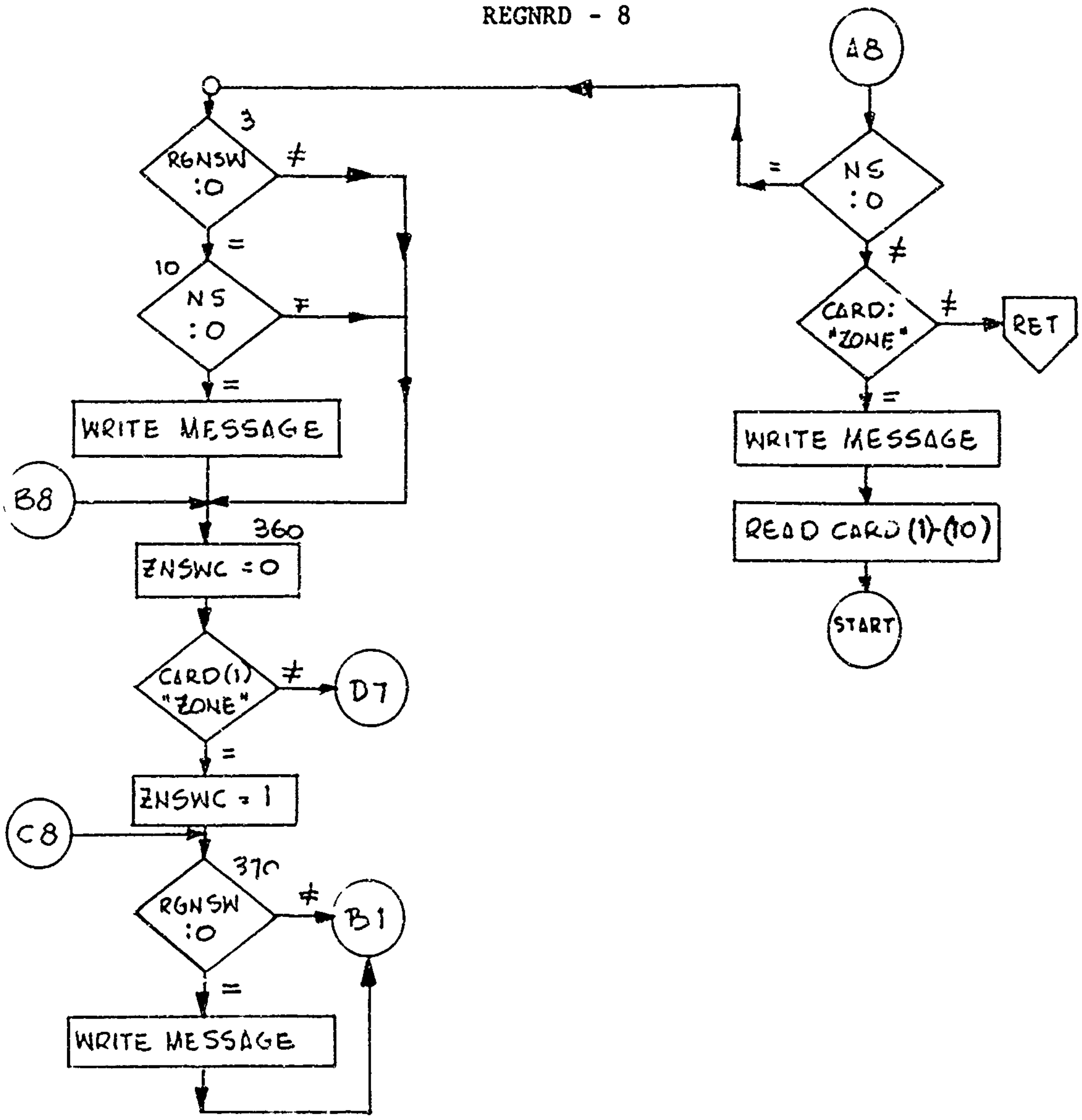
REGNRD - 5


A5
270
WLAB: "C1 ="
=
C1SWCH :0
=
280
C1SWCH = 1
ZNSWC :0
=
CONVRT INTO C1 REGNO
B6
390
≠
WRITE MESSAGE
≠
275
WRITE MESSAGE
ZNSWC :0
≠
=
≠
2900
WLAB: "C2 ="
=
C2SWCH :0
=
3000
C2SWCH = 1
ZNSWC :0
=
CONVRT INTO C2 REGNO
B6
390
≠
WRITE MESSAGE
≠
2950
WRITE MESSAGE
ZNSWC :0
≠
=
≠
290
WLAB: "C3 ="
=
C3SWCH :0
=
300
C3SWCH = 1
ZNSWC :0
=
CONVRT INTO C3 REGNO
B6
390
≠
WRITE MESSAGE
≠
295
WRITE MESSAGE
ZNSWC :0
≠
=
≠
310
WLAB: "C4 ="
=
C4SWCH :0
=
320
C4SWCH = 1
ZNSWC :0
=
CONVRT INTO C4 REGNO
B6
390
≠
WRITE MESSAGE
≠
315
WRITE MESSAGE
ZNSWC :0
≠
=
≠
3300
A6


A6
REGNRD - 6
WLAB: "C5 ="
3300
C5SWCH :0
3400
C5SWCH = 1
ZNSWC :0
CONVRT INTO C5 REGNO
B6
390
WRITE MESSAGE
3350
WRITE MESSAGE
ZNSWC :0
330
WLAB: "EO ="
EOSWCH :0
340
EOSWCH = 1
ZNSWC :0
CONVRT INTO EO REGNO
B6
WRITE MESSAGE
335
WRITE MESSAGE
ZNSWC :0
350
WLAB " "
A7
570
WRITE MESSAGE
B6
640
FIELDN = 2
390
FIELDN ?
670
READ CARD(1)-(10)
C1
50
680
ZNSWC :0
WRITE MESSAGE
370
C8
WLAB FROM CARD (5)
650
FIELDN = 3
660
FIELDN = 4
WLAB FROM CARD (7)
WLAB FROM CARD (9)
ZNSWC :0
B7
575
C7
580
A2
55


A7
REGNRD - 7
570
READ CARD (1)-(10)
NS:0
START
ZNSWC :0
C7
580
ZNGET
ZONGEN
B7
575
GRIDGN
ZONGEN
START
620
ZGETSW :0
J REGNO = JORIG + NZONE
630
JORIG: J REGNO - NZONE
600
J REGNO-1 : J REGNO
WRITE MESSAGE
610
ZGETSW=0
D7
590
ZGETSW :0
20
A1
CARD(1) "REGION"
I 2000 :0
J1 = JREG(REGNO-1)+2
J2 = JREG(REGNO)+1
IF REGNO = 1, J1 = 2
FOR I = J1 TO J2
EL(I) = EG(I)
EG(I) = TEM(I)
TEM(I) = EL(I)
EL(I) = 0
622
JORIG :0
IHYD :0
625
JORIG = JORIG + NZONE
88
REGNO = 1
592
593
NREG = REGNO
JMAX = JREG(NREG)
IHYD :0
REGNO :1
REGNO: NREG-1
REGNO = REGNO + 1
594
JZ = 0
596
IHYD :0
JZ:0
597
JZ: JMAX-1
598
RET
JZ = JZ + 1
595

REGNRD - 8

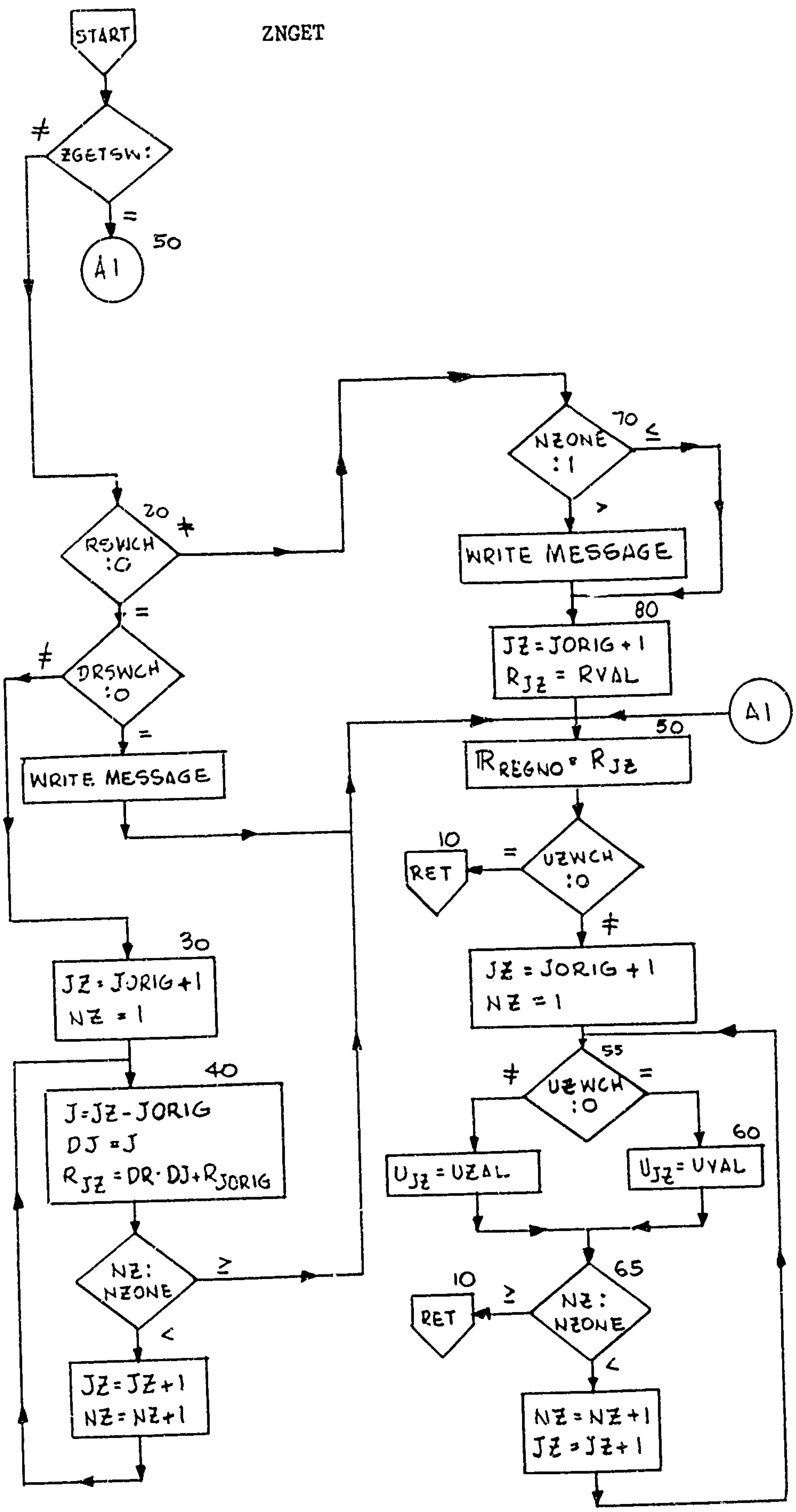

A8
3
RGNSW :0
≠
=
NS :0
10
NS :0
≠
=
CARD: "ZONE"
≠
RET
=
WRITE MESSAGE
WRITE MESSAGE
READ CARD (1)-(10)
START
B8
360
ZNSWC = 0
CARD(1) "ZONE"
≠
D7
=
ZNSWC = 1
C8
370
RGNSW :0
≠
B1
=
WRITE MESSAGE

15. ZNGET

ZNGET is called by REGNRD to generate R's and U's when handling ZONE cards.

```
$IBFTC ZNGET    REF
      SUBROUTINE ZNGET
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
       COMMON /RC/ R(1)
      COMMON /UC/ U(1)
      IF (ZGETSW.NE.0) GO TO 20
       GO TO 50
   10 RETURN
   20 IF (RSWCH.NE.0) GO TO 70
      IF (DRSWCH.NE.0) GO TO 30
      ERFLAG=1
      WRITE (6,1000) REGNO
 1000 FORMAT (53H0 ZONGET FRMT1000    ZONING INFORMATION ON 'ZONE' CARD
     1 38H NOT GIVEN WHEN REQUIRED.  REGION NO.= I5)
      GO TO 50
   30 JZ=JORIG+1
      NZ=1
   40 J= JZ-JORIG
      DJ=J
      R(JZ+1)= DR*DJ +R(JORIG+1)
      IF (NZ.GE.NZONE) GO TO 50
      JZ=JZ+1
      NZ=NZ+1
      GO TO 40
   50 RRG(REGNO)=R(JZ+1)
      IF (UZWCH.EQ.0) GO TO 10
      JZ=JORIG+1
      NZ=1
   55 IF (UZWCH.EQ.0) GO TO 60
      U(JZ+1)=UZAL
      GO TO 65
   60 U(JZ+1)=UVAL
   65 IF (NZ.GE.NZONE) GO TO 10
      NZ=NZ+1
      JZ=JZ+1
      GO TO 55
   70 IF (NZONE.LE.1) GO TO 80
 75   ERFLAG=1
      WRITE (6,1010) REGNO,JORIG
 1010 FORMAT(52H0 ZONGET FRMT1010    CAN'T DEFINE MORE THAN ONE ZONE
     1 41H WHEN R IS GIVEN FOR A ZONE.  REGION NO.= I5,13H LAST J-VALUE
     2  2H = I5)
   80 JZ=JORIG+1
      R(JZ+1)= RVAL
      GO TO 50
      END
```

ZNGET


START
ZGETSW:
A1
50
20
RSWCH :0
DRSWCH :0
WRITE MESSAGE
30
JZ=JORIG+1
NZ=1
40
J=JZ-JORIG
DJ=J
R_{JZ}=DR·DJ+R_{JORIG}
NZ: NZONE
JZ=JZ+1
NZ=NZ+1
70
NZONE :1
WRITE MESSAGE
80
JZ=JORIG+1
R_{JZ}=RVAL
A1
50
R_{REGNO}=R_{JZ}
10
RET
UZWCH :0
JZ=JORIG+1
NZ=1
55
UZWCH :0
U_{JZ}=UZAL
60
U_{JZ}=UVAL
65
10
RET
NZ: NZONE
NZ=NZ+1
JZ=JZ+1

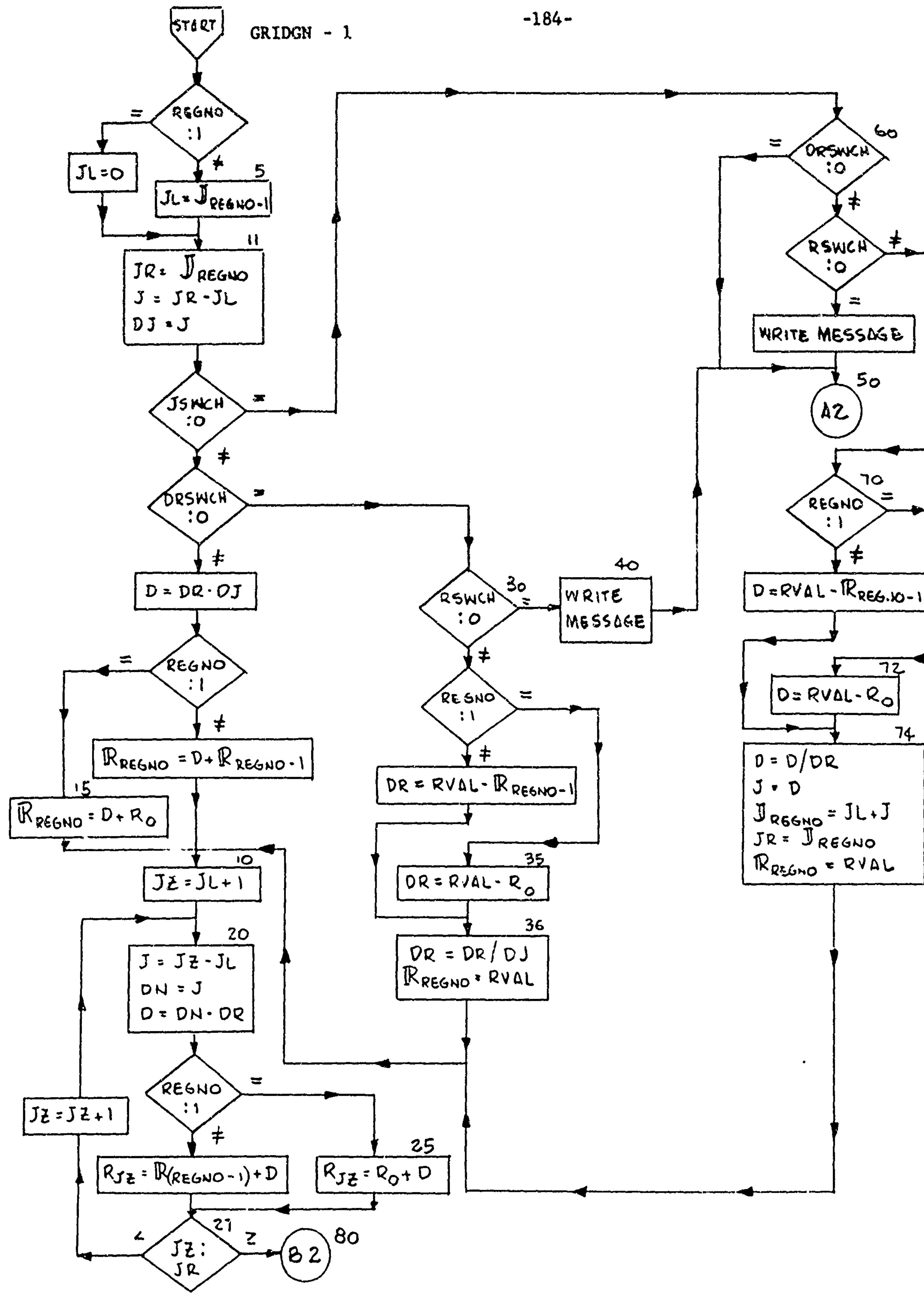
16. GRIDGN

GRIDGN is called by REGNRD to generate R's and U's when handling REGION cards.

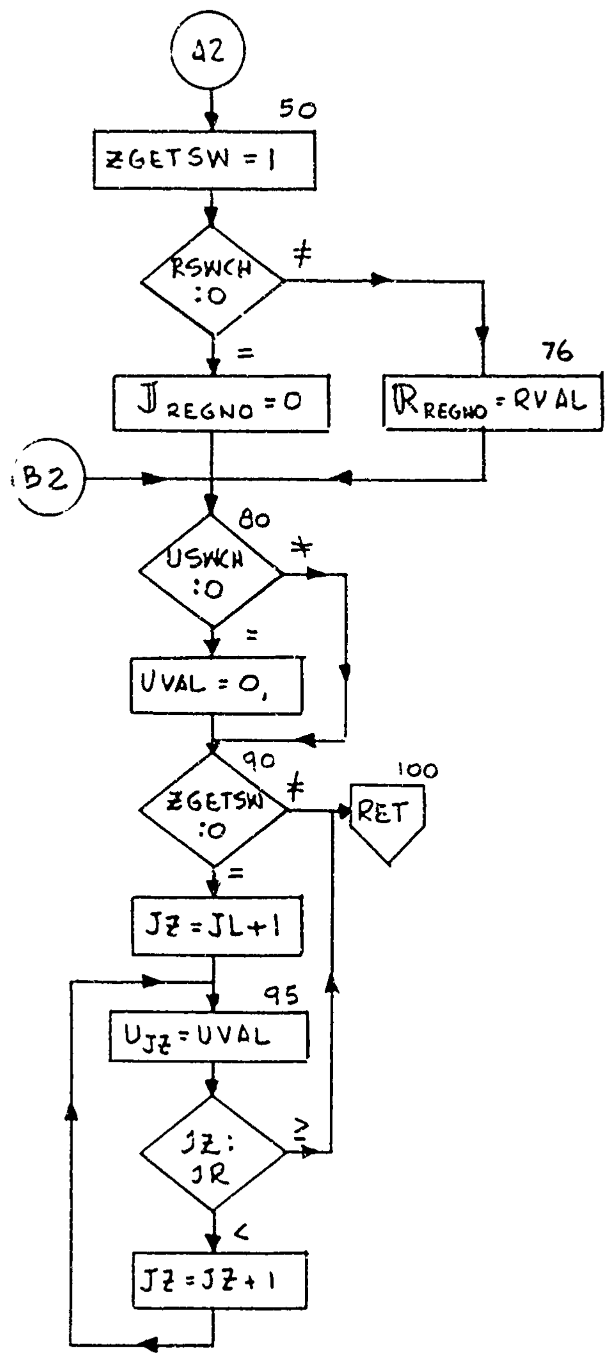
```
$IBFTC GRIDGN  REF
      SUBROUTINE GRIDGN
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
       COMMON /RC/ R(1)
      COMMON /UC/ U(1)
       IF(REGNO.NE.1) GO TO 5
       JL=0
       GO TO 11
    5 JL=JREG(REGNO-1)
   11 JR=JREG(REGNO)
      J=JR-JL
      DJ=J
      IF (JSWCH.EQ.0) GO TO 60
      IF (DRSWCH.EQ.0) GO TO 30
      D=DR*DJ
      IF (REGNO.EQ.1) GO TO 15
      RRG(REGNO)=D+RRG(REGNO-1)
      GO TO 10
 15   RRG(REGNO)=D+R(1)
   10 JZ=JL+1
   20 J= JZ-JL
      DN=J
      D=DN*DR
      IF (REGNO.EQ.1) GO TO 25
      R(JZ+1) = RRG(REGNO-1) + D
      GO TO 27
 25   R(JZ+1)=R(1)+D
 27   IF (JZ.GE.JR) GO TO 80
      JZ=JZ+1
      GO TO 20
   30 IF (RSWCH.EQ.0) GO TO 40
      IF (REGNO.EQ.1) GO TO 35
      DR= RVAL-RRG(REGNO-1)
      GO TO 36
 35   DR=RVAL-R(1)
 36   DR=DR/DJ
      RRG(REGNO)=RVAL
      GO TO 10
   40 ERFLAG=1
      WRITE (6,1000) REGNO
 1000 FORMAT (45H0 GRIDGN FRMT1000   INSUFF. DATA FOR REG. NO. I5,
     1 16H.  ONLY J INPUT. )
   50 ZGETSW=1
      IF (RSWCH.NE.0) GO TO 76
      JREG(REGNO)=0
      GO TO 80
   60 IF (DRSWCH.EQ.0) GO TO 50
```

```
      IF (RSWCH.NE.0) GO TO 70
      ERFLAG=1
      WRITE (6,1010) REGNO
 1010 FORMAT (52H0 GRIDGN FRMT1010   INSUFF. DATA FOR REGION. ONLY DR
     1 18H INPUT.  REG. NO.= I5)
      GO TO 50
 70   IF (REGNO.EQ.1) GO TO 72
      D=RVAL-RRG(REGNO-1)
      GO TO 74
 72   D=RVAL-R(1)
 74   D=D/DR
      J=D
      JREG(REGNO)=JL+J
      JR=JREG(REGNO)
      RRG(REGNO)=RVAL
      GO TO 10
 76   RRG(REGNO)=RVAL
   80 IF (USWCH.NE.0) GO TO 90
      UVAL=0.
   90 IF (ZGETSW.NE.0) GO TO 100
      JZ=JL+1
   95 U(JZ+1)=UVAL
      IF (JZ.GE.JR) GO TO 100
      JZ=JZ+1
      GO TO 95
  100 RETURN
      END
```

GRIDGN - 1


START
REGNO :1
JL=0
5
JL = 𝕁REGNO-1
11
JR = 𝕁REGNO
J = JR-JL
DJ = J
JSWCH :0
DRSWCH :0
D = DR·DJ
REGNO :1
ℝREGNO = D+ℝREGNO-1
15
ℝREGNO = D+R0
10
JZ = JL+1
20
J = JZ-JL
DN = J
D = DN·DR
REGNO :1
JZ = JZ+1
RJZ = ℝ(REGNO-1)+D
25
RJZ = R0+D
21
JZ : JR
80
B2
30
RSWCH :0
40
WRITE MESSAGE
REGNO :1
DR = RVAL-ℝREGNO-1
35
DR = RVAL-R0
36
DR = DR/DJ
ℝREGNO = RVAL
60
DRSWCH :0
RSWCH :0
WRITE MESSAGE
50
A2
70
REGNO :1
D = RVAL-ℝREGNO-1
72
D = RVAL-R0
74
D = D/DR
J = D
𝕁REGNO = JL+J
JR = 𝕁REGNO
ℝREGNO = RVAL

GRIDGN - 2


A2
50
ZGETSW = 1
RSWCH :0
≠
=
76
J REGNO = 0
R REGNO = RVAL
B2
80
USWCH :0
≠
=
UVAL = 0.
90
ZGETSW :0
≠
100
RET
=
JZ = JL+1
95
U JZ = UVAL
JZ: JR
≥
<
JZ = JZ+1

17. ZONGEN

ZONGEN is called by REGNRD to generate the zone variables other than R and U for all the zones.

```
$IBFTC ZONGEN  REF
      SUBROUTINE ZONGEN(C)
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
       COMMON /RC/ R(1)
      COMMON /TEMC/ TEM(1)
      COMMON /TAMC/ TAM(1)
      COMMON /VLC/ VL(1)
      COMMON /PRC/ PR(1)
      COMMON /EGC/ EG(1)
      COMMON /KPC/ KP(1)
      COMMON /KMC/ KM(1)
      COMMON /DMASSC/ DMASS(1)
      COMMON /MATC/ MAT(1)
      INTEGER PCOMP,ECOMP
       DIMENSION C(1)
      IF (ZNSWC.NE.0) GO TO 420
      IF (REGNO.EQ.1) GO TO 2
      JZ=JREG(REGNO-1)
      GO TO 4
    2 JZ=0
    4 JL=JZ
      JR=JREG(REGNO)
      ZNQSW=0
      IF (TSWCH.EQ.0) GO TO 10
      IF (MSWCH.NE.0) GO TO 20
      IF (VSWCH.NE.0) GO TO 5
      IF (RHSWCH.EQ.0) GO TO 80
      VVAL=1./RHVAL
    5 PCOMP=1
      GO TO 47
   10 IF (MSWCH.EQ.0) GO TO 120
      IF (ZGETSW.EQ.0) GO TO 30
      ERFLAG=1
      WRITE (6,1000) REGNO
 1000 FORMAT (1H0,44H ZONGEN FRMT1000  INSUFFICIENT INFORMATION -
     1,34H CAN'T COMPUTE V FOR REGION NUMBER ,I5 /)
      WRITE (6,1) (CARD(I),I=1,10)
    1  FORMAT (A6,F6.0,4(A3,E12.6))
      GO TO 260
   20 IF (ZGETSW.NE.0) GO TO 260
      ASSIGN  5  TO LOC
      GO TO 200
   30 ASSIGN 40 TO LOC
      GO TO 200
   40 IF (PSWCH.EQ.0) GO TO 50
       JL1=JL+1
       MAT(JL1+1)=NEOS
      CALL GETVAR(1,2,PVAL,VVAL,JL1,TVAL,C)
```

```
 45 PCOMP=0
 47 ECOMP=1
    KCOMP=1
    GO TO 260
 50 IF (ESWCH.EQ.0) GO TO 60
     JL1=JL+1
     MAT(JL1+1)=NEOS
    CALL GETVAR(2,2,EVAL,VVAL,JL1,TVAL,C)
 55 PCOMP=1
    ECOMP=0
    KCOMP=1
    GO TO 260
 60 IF (KSWCH.EQ.0) GO TO 70
     JL1=JL+1
     MAT(JL1+1)=NEOS
    CALL GETVAR (3,2,KVAL,VVAL,JL1,TVAL,C)
 65 PCOMP=1
    ECOMP=1
    KCOMP=0
    GO TO 260
 70 ZNQSW=2
    GO TO 260
 80 IF (PSWCH.EQ.0) GO TO 90
     JL1=JL+1
     MAT(JL1+1)=NEOS
    CALL GETVAR (1,1,PVAL,TVAL,JL1,VVAL,C)
    GO TO 45
 90 IF (ESWCH.EQ.0) GO TO 100
     JL1=JL+1
     MAT(JL1+1)=NEOS
    CALL GETVAR (2,1,EVAL,TVAL,JL1,VVAL,C)
    GO TO 55
100 IF (KSWCH.EQ.0) GO TO 110
     JL1=JL+1
     MAT(JL1+1)=NEOS
    CALL GETVAR (3,1,KVAL,TVAL,JL1,VVAL,C)
    GO TO 65
110 ZNQSW=1
    GO TO 260
120 IF (VSWCH.NE.0) GO TO 40
    IF (RHSWCH.EQ.0) GO TO 130
    VVAL=1./RHVAL
    GO TO 40
130 IF (PSWCH.EQ.0) GO TO 160
    IF (ESWCH.EQ.0) GO TO 140
    CALL GETTV (1,2,JL,PVAL,EVAL,TVAL,VVAL)
135 PCOMP=0
    ECOMP=0
    KCOMP=1
    GO TO 260
140 IF (KSWCH.EQ.0) GO TO 150
    CALL GETTV (1,3,JL,PVAL,KVAL,TVAL,VVAL)
```

```
145 PCOMP=0
    ECOMP=1
    KCOMP=0
    GO TO 260
150 ZNQSW=4
    GO TO 260
160 IF (ESWCH.EQ.0) GO TO 180
    IF (KSWCH.EQ.0) GO TO 170
    CALL GETTV (2,3,JL,EVAL,KVAL, TVAL,VVAL)
165 PCOMP=1
    ECOMP=0
    KCOMP=0
    GO TO 260
170 ZNQSW=3
    GO TO 260
180 IF (KSWCH.EQ.0) GO TO 190
    ZNQSW=5
    GO TO 260
190 ZNQSW=6
    GO TO 260
200 DELT=DELTA
    IF (REGNO.EQ.1) GO TO 210
    D=RRG(REGNO-1)
    GO TO 215
210 D=R(1)
215 IF (DELTA.GT.1) GO TO 218
    D=RRG(REGNO)-D
    GO TO 240
218 IF (DELTA.GT.2) GO TO 220
    D=  (RRG(REGNO)-D)*(RRG(REGNO)+D)
    GO TO 240
220 D= (RRG(REGNO)-D)*(RRG(REGNO)**2+RRG(REGNO)*D+D**2)
240 VVAL=D/DELT/DMVAL
    GO TO LOC,   (5,40)
260 IF (ZNSWC.NE.0) GO TO 820
    IF (ZGETSW.NE.0) GO TO 300
    JZ=JL
262 MAT(JZ+2)=NEOS
    IF (JZ.GE.JR-1) GO TO  265
    JZ=JZ+1
    GO TO 262
265 IF (ZNQSW.GT.5) GO TO 290
    IF (ZNQSW.GT.4) GO TO 310
    IF (ZNQSW.GT.3) GO TO 320
    IF (ZNQSW.GT.2) GO TO 340
    IF (ZNQSW.GT.1) GO TO 360
    JZ=JL
270 TEM(JZ+2)=TVAL
    IF (JZ.EQ.JL) GO TO 275
    IF(IHYD.EQ.0)TAM(JZ+1)=TVAL
275 IF (JZ.GE.JR-1) GO TO 280
    JZ=JZ+1
    GO TO 270
```

```
 280 IF (ZNQSW.EQ.0) GO TO 360
 290 RETURN
 300 IF (ZNQSW.NE.0) GO TO 290
     GO TO 370
310  JZ=JL+1
      IF(IHYD.NE.0) RETURN
 315 KP(JZ+1)=KVAL
     KM(JZ+1)=KVAL
     IF (JZ.GE.JR-1) GO TO 290
     JZ=JZ+1
     GO TO 315
 320 JZ=JL
 325 PR(JZ+2)=PVAL
     IF (JZ.GE.JR-1) GO TO 330
     JZ=JZ+1
     GO TO 325
 330 IF (ZNQSW.NE.0) GO TO 290
 340 JZ=JL
 345 EG(JZ+2)=EVAL
     IF (JZ.GE.JR-1) GO TO 350
     JZ=JZ+1
     GO TO 345
 350 IF (ZNQSW.NE.0) GO TO 290
     GO TO 310
 360 JZ=JL
 365 VL(JZ+2)=VVAL
     IF (JZ.GE.JR-1) GO TO 368
     JZ=JZ+1
     GO TO 365
368  ASSIGN 370 TO LLC
     GO TO  401
 370 IF (PCOMP.EQ.0) GO TO 380
     CALL PEK (1,NEOS,TVAL,VVAL,JL,0,PVAL,C)
 380 IF (ECOMP.EQ.0) GO TO 390
     CALL PEK (2,NEOS,TVAL,VVAL,JL,0,EVAL,C)
 390 IF (KCOMP.EQ.0) GO TO 400
     IF(IHYD.EQ.0)CALL PEK (3,NEOS,TVAL,VVAL,JL,0,KVAL,C)
 400 IF (ZGETSW.NE.0) GO TO 290
     IF (ZNQSW .EQ.0) GO TO 320
     GO TO 290
401  JZ=JL
     DELT=DELTA
402  D=R(JZ+2)-R(JZ+1)
     IF (DELTA.GT.1) GO TO 403
     GO TO 405
403  IF (DELTA.GT.2) GO TO 404
     D=D*(R(JZ+2)+R(JZ+1))
     GO TO 405
404  D=D*(R(JZ+2)**2+R(JZ+2)*R(JZ+1)+R(JZ+1)**2)
405  IF (ZNSWC.EQ.0) GO TO 409
     DMASS(JZ+2)=D/DELT/VZAL
     GO TO 407
409  DMASS(JZ+2)=D/DELT/VVAL
     IF (JZ.GE.JR-1) GO TO 406
```

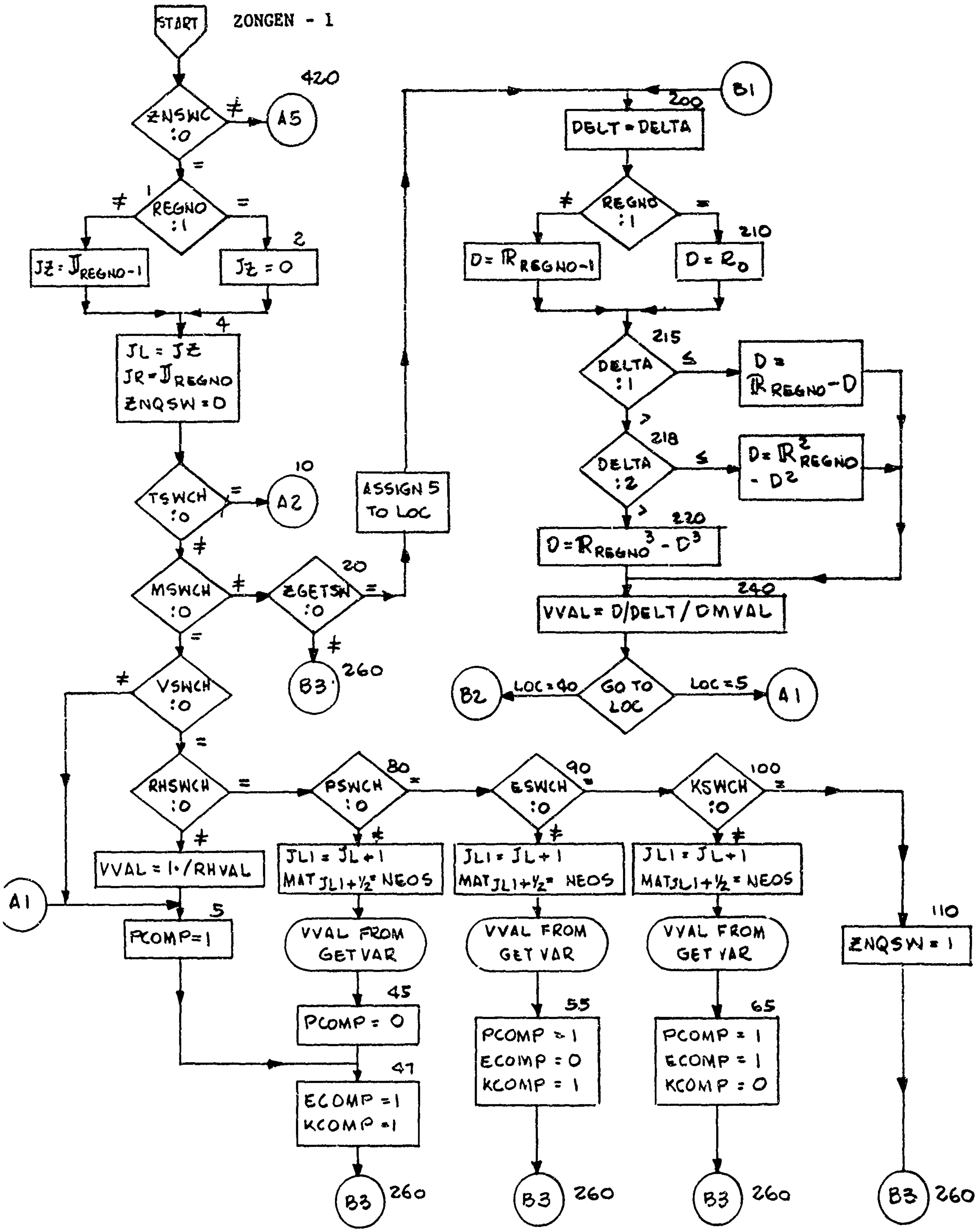
```
408  JZ=JZ+1
     GO TO 402
406  GO TO LLC, (370,260)
407  IF (JZ.GE.JR) GO TO 406
     GO TO 408
 420 JR=JORIG+NZONE-1
     JZ = JORIG
     IF (TZWCH.NE.0) GO TO 740
     IF (MZWCH.NE.0) GO TO 425
     IF (VZWCH.NE.0) GO TO 660
     IF (RHZWCH.NE.0) GO TO 440
     IF (PZWCH.NE.0) GO TO 450
     IF (EZWCH.NE.0) GO TO 530
     IF (KZWCH.NE.0) GO TO 600
     IF (ZNQSW.EQ.0) GO TO 870
     ERFLAG=1
     WRITE (6,1020) REGNO,JORIG
     WRITE (6,1) (CARD(I),I=1,10)
1020 FORMAT (1H0,46H ZONGEN FRMT1020  NEITHER REGION NOR ZONE DATA
    1,  20H   LAST J VALUE WAS I5 /)
     GO TO 290
 425 ASSIGN 660 TO LOC
 430 DELT=DELTA
     IF (DELTA.GT.1) GO TO 432
     D = R(JZ+2)-R(JZ+1)
     GO TO 436
 432 IF (DELTA.GT.2) GO TO 434
     D = (R(JZ+2)-R(JZ+1))*(R(JZ+2)+R(JZ+1))
     GO TO 436
 434  D = (R(JZ+2)-R(JZ+1))*(R(JZ+2)**2+R(JZ+2)*R(JZ+1)+R(JZ+1)**2)
 436 VZAL=D/DELT/DMZAL
     GO TO LOC, (660,675)
 440 VZAL=1./RHZAL
     GO TO 660
 450 IF (EZWCH.EQ.0) GO TO 460
 455 CALL GETTV (1,2,JORIG,PZAL,EZAL,TZAL,VZAL)
     PCOMP=0
     ECOMP=0
     KCOMP=1
     GO TO 720
 460 IF (KZWCH.EQ.0) GO TO 470
 465 CALL GETTV (1,3,JORIG,PZAL,KZAL,TZAL,VZAL)
     PCOMP=0
     ECOMP=1
     KCOMP=0
     GO TO 720
 470 IF (ZNQSW.EQ.3) GO TO 500
     IF (ZNQSW.EQ.5) GO TO 510
     IF (ZNQSW.EQ.1) GO TO 480
     IF (ZNQSW.EQ.2) GO TO 490
     IF (ZNQSW.EQ.0) GO TO 520
     ERFLAG=1
     WRITE (6,1030) REGNO,JORIG
     WRITE (6,1) (CARD(I),I=1,10)
```

```
1030 FORMAT (1H0,48H ZONGEN FRMT1030  ONLY P INPUT INSUFFICIENT DATA
    1,12H   REG. NO.= I5,12H     JVALUE= I5 /)
     GO TO 290
 480 TZAL=TVAL
     GO TO 710
 490 VZAL=VVAL
     GO TO 660
 500 EZAL=EVAL
     GO TO 455
 510 KZAL=KVAL
     GO TO 465
 520 JZ=JORIG
 525 PR(JZ+2)=PZAL
     IF (JZ.EQ.JR) GO TO 290
     JZ=JZ+1
     GO TO 525
 530 IF (KZWCH.EQ.0) GO TO 540
 535 CALL GETTV (2,3,JORIG,EZAL,KZAL,TZAL,VZAL)
     PCOMP=1
     ECOMP=0
     KCOMP=0
     GO TO 720
 540 IF (ZNQSW.EQ.0) GO TO 550
     IF (ZNQSW.EQ.1) GO TO 560
     IF (ZNQSW.EQ.2) GO TO 570
     IF (ZNQSW.EQ.4) GO TO 580
     IF (ZNQSW.EQ.5) GO TO 590
     ERFLAG=1
     WRITE (6,1040) REGNO,JORIG
     WRITE (6,1) (CARD(I),I=1,10)
1040 FORMAT (1H0,50H ZONGEN FRMT1040  ONLY E INPUT - INSUFFICIENT DATA
    1,10H REG. NO.= I5,16H   LAST JVALUE= I5 /)
     GO TO 290
 550 JZ=JORIG
 555 EG(JZ+2)=EZAL
     IF (JZ.GE.JR) GO TO 290
     JZ=JZ+1
     GO TO 555
 560 TZAL=TVAL
     GO TO 770
 570 VZAL=VVAL
     GO TO 690
 580 PZAL=PVAL
     GO TO 455
 590 KZAL=KVAL
     GO TO 535
 600 IF (ZNQSW.EQ.0) GO TO 610
     IF  (ZNQSW.EQ.1) GO TO 620
     IF  (ZNQSW.EQ.2) GO TO 630
     IF  (ZNQSW.EQ.3) GO TO 640
```

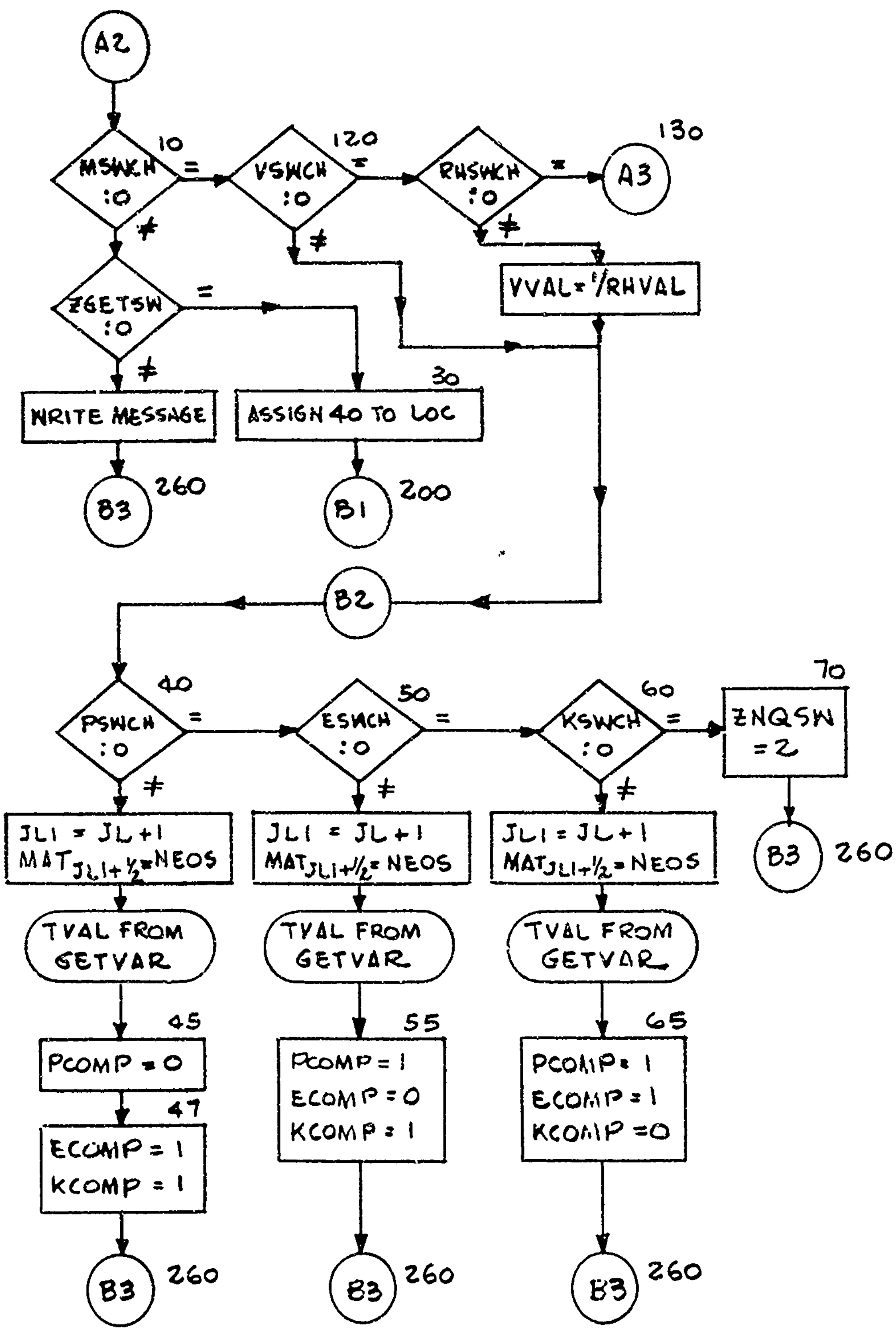
```
      IF  (ZNQSW.EQ.4) GO TO 650
      ERFLAG=1
      WRITE (6,1050) REGNO,JORIG
      WRITE (6,1) (CARD(I),I=1,10)
 1050 FORMAT (1H0,50H ZONGEN FRMT1050  ONLY K INPUT - INSUFFICIENT DAT
     1,10H REG. NO.= I5,17H    LAST J VALUE= I5 /)
      GO TO 290
  610 JZ=JORIG
       IF(IHYD.NE.0) RETURN
  615 KP(JZ+1)=KZAL
      IF (JZ.GE.JR) GO TO 290
      JZ=JZ+1
      GO TO 615
  620 TZAL=TVAL
      GO TO 790
  630 VZAL=VVAL
      GO TO 680
  640 EZAL=EVAL
      GO TO 535
  650 PZAL=PVAL
      GO TO 465
  660 IF (PZWCH.NE.0) GO TO 700
      IF (EZWCH.NE.0) GO TO 690
      IF (KZWCH.NE.0) GO TO 680
      IF (ZNQSW.LE.1) GO TO 670
      IF (ZNQSW.NE.3) GO TO 662
      EZAL=EVAL
      GO TO 690
 662  IF (ZNQSW.NE.4) GO TO 664
      PZAL=PVAL
      GO TO 700
 664  IF (ZNQSW.GT.5) GO TO 666
      KZAL=KVAL
      GO TO 680
 666  ERFLAG=1
      WRITE (6,1060) REGNO,JORIG
      WRITE (6,1) (CARD(I),I=1,10)
 1060 FORMAT (1H0,46H ZONGEN FRMT1060  NEITHER REGION NOR ZONE DATA
     1,37H SUFFICIENT TO DEFINE T.  REGION NO.= I5,16H   LAST JVALUE= ,
     2 I5 /)
      GO TO 290
  670 TZAL=TVAL
  675 PCOMP=1
      ECOMP=1
      KCOMP=1
      GO TO 720
  680 PCOMP=1
      ECOMP=1
      KCOMP=0
       JORIG1=JORIG+1
       MAT(JORIG1+1)=NEOS
      CALL GETVAR (3,2,KZAL,VZAL,JORIG1,TZAL,C)
       IF (IHYD.EQ.0) TAM(JORIG+1) = TZAL
      GO TO 720
  690 PCOMP=1
      ECOMP=0
      KCOMP=1
```

```
      JORIG1=JORIG+1
      MAT(JORIG1+1)=NEOS
      CALL GETVAR (2,2,EZAL,VZAL,JORIG1,TZAL,C)
      GO TO 720
  700 PCOMP=0
      ECOMP=1
      KCOMP=1
      JORIG1=JORIG+1
      MAT(JORIG1+1)=NEOS
      CALL GETVAR (1,2,PZAL,VZAL,JORIG1,TZAL,C)
      GO TO 720
  710 JORIG1=JORIG+1
      MAT(JORIG1+1)=NEOS
      CALL GETVAR (1,1,PZAL,TZAL,JORIG1,VZAL,C)
      PCOMP=0
      ECOMP=1
      KCOMP=1
  720 JZ=JORIG
  725 TEM(JZ+2)=TZAL
      VL(JZ+2)=VZAL
      IF (NZONE.LT.2.OR.JZ.EQ.JORIG) GO TO 730
      IF (IHYD.EQ.0) TAM(JZ+1) = TZAL
  730 IF (JZ.GE.JR) GO TO 732
      JZ=JZ+1
      GO TO 725
  732 JZ=JORIG
      DELT=DELTA
      ASSIGN 260 TO LLC
      GO TO 402
  740 IF (MZWCH.EQ.0) GO TO 750
      ASSIGN 675 TO LOC
      GO TO 430
  750 IF (VZWCH.NE.0) GO TO 675
      IF (RHZWCH.EQ.0) GO TO 760
      VZAL=1./RHZAL
      GO TO 675
  760 IF (PZWCH.EQ.0) GO TO 780
      GO TO 710
  770 JORIG1=JORIG+1
      MAT(JORIG1+1)=NEOS
      CALL GETVAR (2,1,EZAL,TZAL,JORIG1,VZAL,C)
      PCOMP=1
      ECOMP=0
      KCOMP=1
      GO TO 720
  780 IF (EZWCH.NE.0) GO TO 770
      IF (KZWCH.EQ.0) GO TO 800
  790 JORIG1=JORIG+1
      MAT(JORIG1+1)=NEOS
      CALL GETVAR (3,1,KZAL,TZAL,JORIG1,VZAL,C)
      PCOMP=1
      ECOMP=1
      KCOMP=0
      GO TO 720
  800 IF (ZNQSW.EQ.0) GO TO 675
      IF (ZNQSW.EQ.2) GO TO 810
      IF (ZNQSW.NE.3) GO TO 802
```

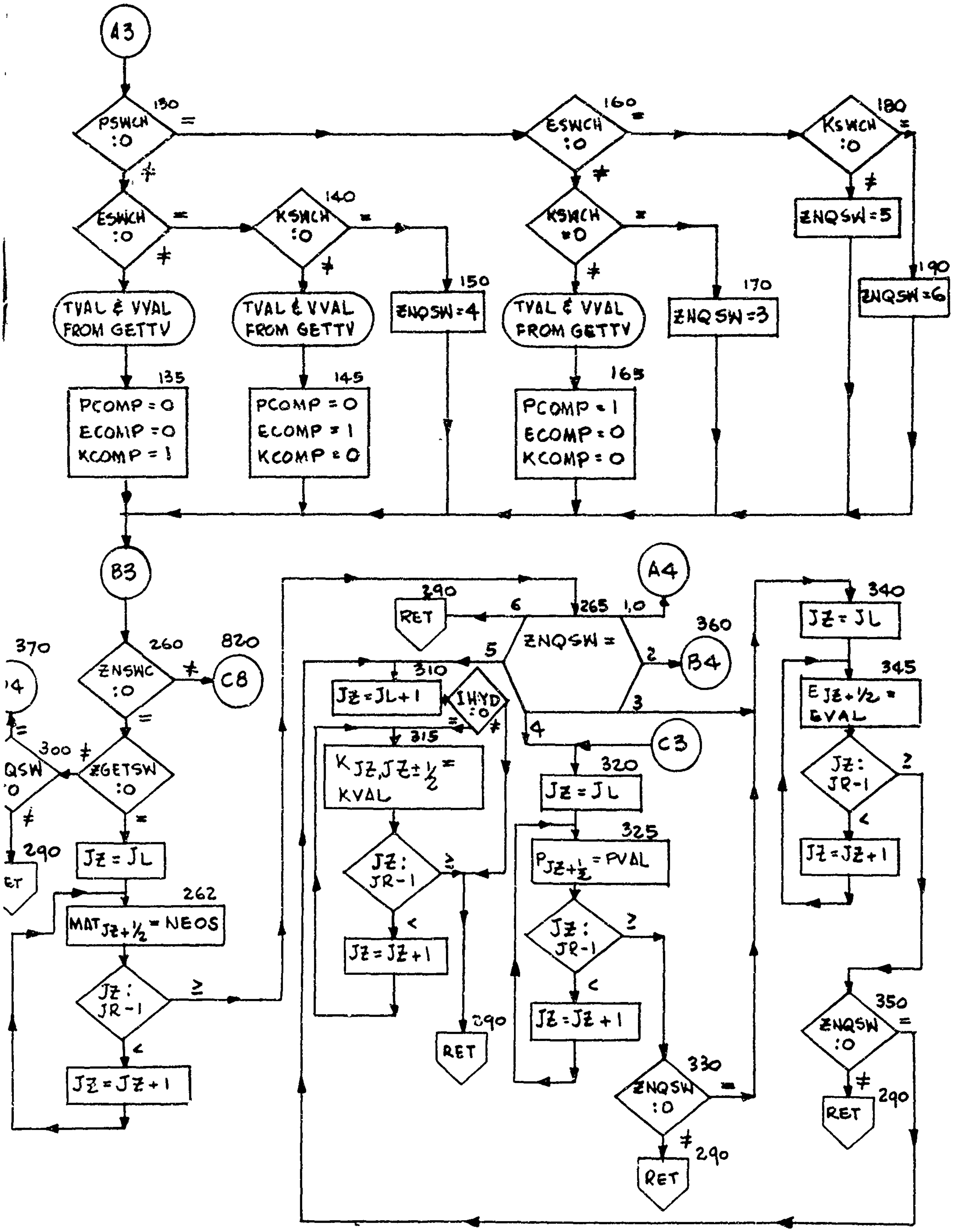
```
      EZAL=EVAL
      GO TO 770
  802 IF (ZNQSW.NE.4) GO TO 804
      PZAL=PVAL
      GO TO 710
  804 IF (ZNQSW.GT.5) GO TO 806
      KZAL=KVAL
      GO TO 790
  806 ERFLAG=1
      WRITE (6,1070) REGNO,JORIG
      WRITE (6,1) (CARD(I),I=1,10)
 1070 FORMAT (1H0,41H ZONGEN FRMT1070  NEITHER REGION NOR ZONE
     1,36H SUFFICIENT TO DEFINE V.    REG. NO.= I5, 16H    LAST JVALUE=
     2 I5 /)
      GO TO 290
  810 VZAL=VVAL
      GO TO 675
  820 IF (PCOMP.EQ.0) GO TO 830
      CALL PEK (1,NEOS,TZAL,VZAL,JORIG,0,PZAL,C)
  830 IF (ECOMP.EQ.0) GO TO 840
      CALL PEK (2,NEOS,TZAL,VZAL,JORIG,0,EZAL,C)
  840 IF (KCOMP.EQ.0) GO TO 850
       IF (IHYD.EQ.0) CALL PEK(3,NEOS,TZAL,VZAL,JORIG,0,KZAL,C)
  850 JZ=JORIG
  855 PR(JZ+2)=PZAL
      EG(JZ+2)=EZAL
      IF (JZ.LE.JORIG ) GO TO 856
       IF (IHYD.NE.0) GO TO 856
      KP(JZ+1)=KZAL
      KM(JZ+1) = KZAL
  856 IF (JZ.GE.JR) GO TO 860
      JZ=JZ+1
      GO TO 855
  860 JZ=JORIG
  865 MAT(JZ+2)=NEOS
      IF (JZ.GE.JR) GO TO 290
      JZ=JZ+1
      GO TO 865
  870 TZAL=TVAL
      VZAL=VVAL
      GO TO 720
      END
```


START
ZONGEN - 1
420
ZNSWC :0
A5
REGNO :1
JZ = $\mathbb{J}_{REGNO-1}$
2
JZ = 0
4
JL = JZ
JR = $\mathbb{J}_{REGNO}$
ZNQSW = 0
10
TSWCH :0
A2
MSWCH :0
20
ZGETSW :0
B3 260
ASSIGN 5 TO LOC
VSWCH :0
RHSWCH :0
VVAL = 1./RHVAL
A1
5
PCOMP=1
80
PSWCH :0
JL1 = JL+1
MAT$_{JL1+1/2}$ = NEOS
VVAL FROM GETVAR
45
PCOMP = 0
47
ECOMP = 1
KCOMP = 1
B3 260
90
ESWCH :0
JL1 = JL+1
MAT$_{JL1+1/2}$ = NEOS
VVAL FROM GET VAR
55
PCOMP = 1
ECOMP = 0
KCOMP = 1
B3 260
100
KSWCH :0
JL1 = JL+1
MAT$_{JL1+1/2}$ = NEOS
VVAL FROM GET VAR
65
PCOMP = 1
ECOMP = 1
KCOMP = 0
B3 260
110
ZNQSW = 1
B3 260
B1
200
DELT = DELTA
REGNO :1
D = $\mathbb{R}_{REGNO-1}$
210
D = R_0
215
DELTA :1
D = $\mathbb{R}_{REGNO} - D$
218
DELTA :2
D = $\mathbb{R}^2_{REGNO} - D^2$
220
D = $\mathbb{R}_{REGNO}^3 - D^3$
240
VVAL = D/DELT/DMVAL
GO TO LOC
LOC = 40
B2
LOC = 5
A1

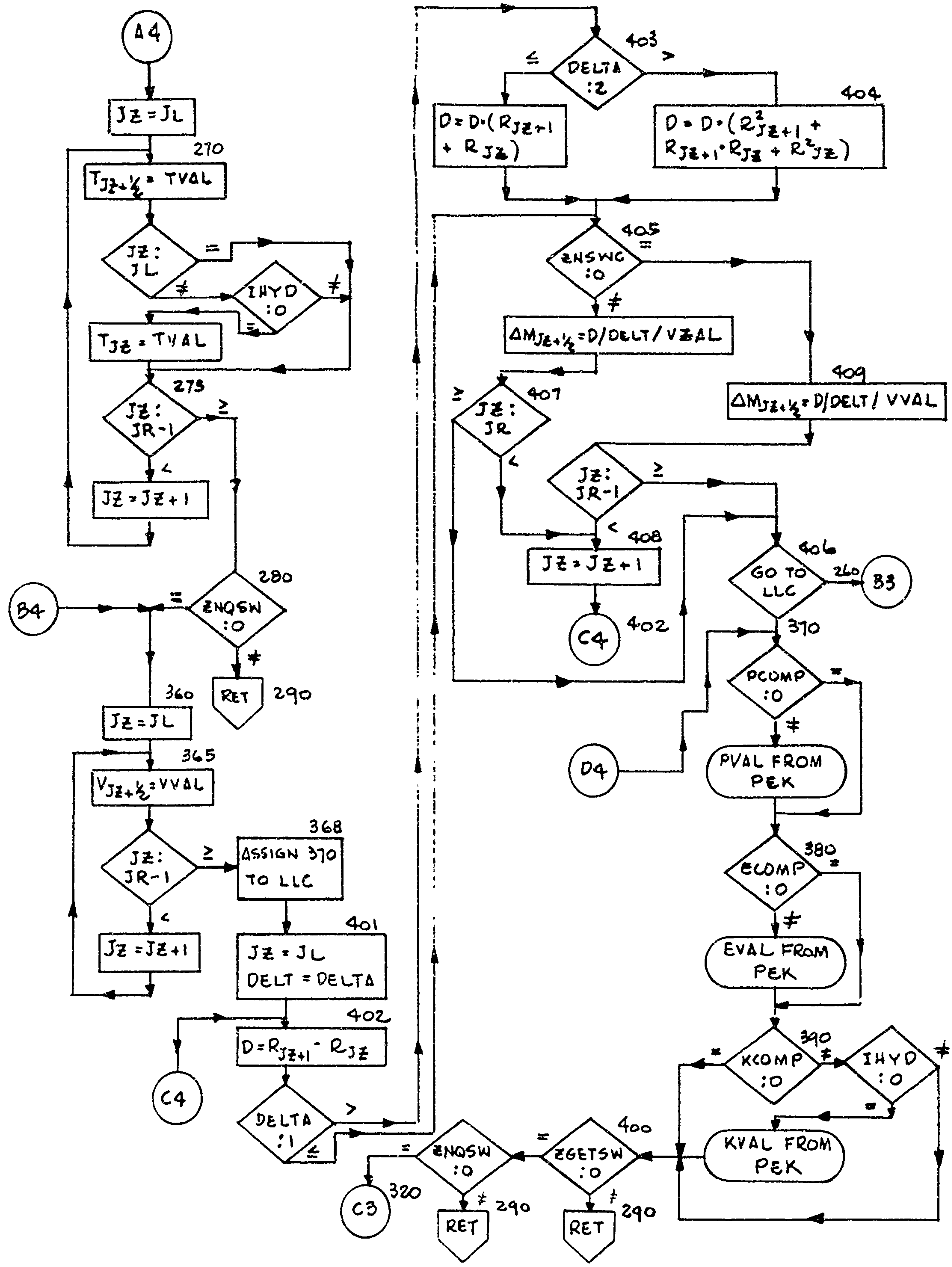
ZONGEN - 2


A2
MSWCH :0
10
VSWCH :0
120
RHSWCH :0
130
A3
ZGETSW :0
VVAL=1/RHVAL
WRITE MESSAGE
ASSIGN 40 TO LOC
30
B3
260
B1
200
B2
PSWCH :0
40
ESWCH :0
50
KSWCH :0
60
ZNQSW =2
70
JL1 = JL+1
MAT JL1+½=NEOS
TVAL FROM GETVAR
PCOMP = 0
45
ECOMP = 1
KCOMP = 1
47
PCOMP = 1
ECOMP = 0
KCOMP = 1
55
PCOMP = 1
ECOMP = 1
KCOMP = 0
65
B3
260

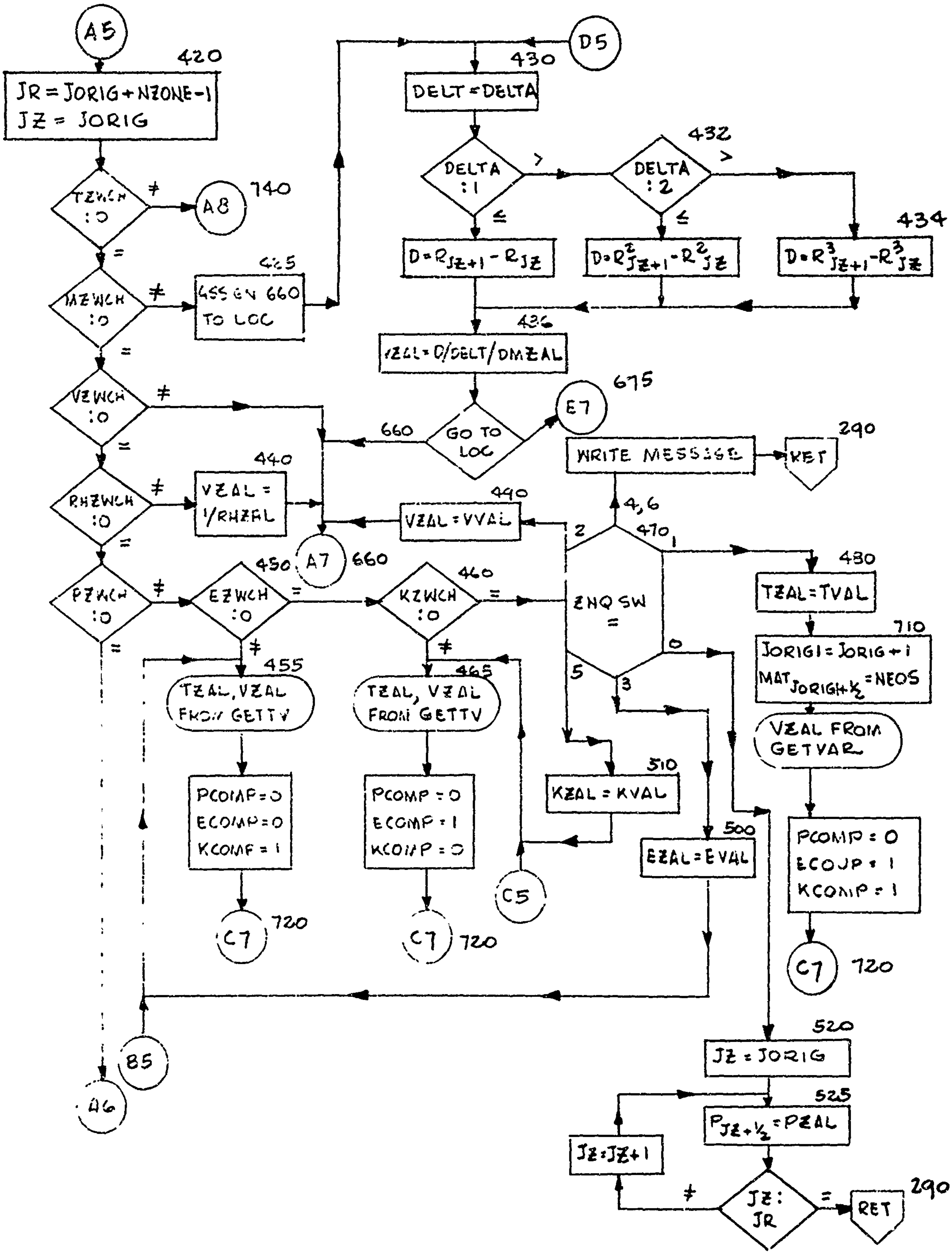
ZONGEN - 3


A3
PSWCH :0
ESWCH :0
KSWCH :0
TVAL & VVAL FROM GETTV
PCOMP = 0
ECOMP = 0
KCOMP = 1
PCOMP = 0
ECOMP = 1
KCOMP = 0
ZNQSW = 4
PCOMP = 1
ECOMP = 0
KCOMP = 0
ZNQSW = 3
ZNQSW = 5
ZNQSW = 6
B3
ZNSWC :0
C8
ZGETSW :0
JZ = JL
MAT JZ+1/2 = NEOS
JZ : JR-1
JZ = JZ+1
RET
ZNQSW =
A4
B4
C3
IHYD :0
JZ = JL+1
K JZ,JZ±1/2 = KVAL
PJZ+1/2 = PVAL
E JZ+1/2 = EVAL
ZNQSW :0

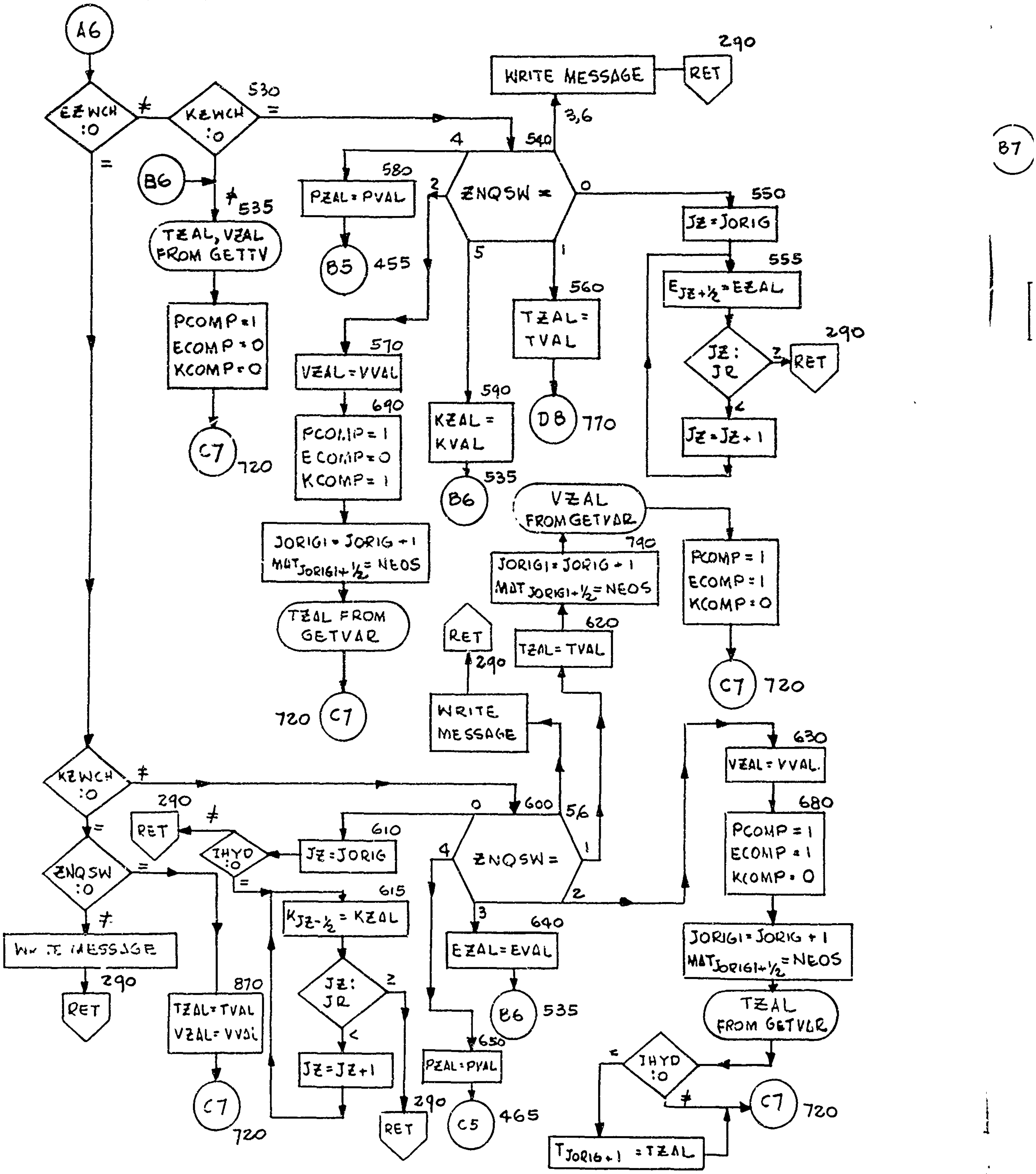
ZONGEN - 4

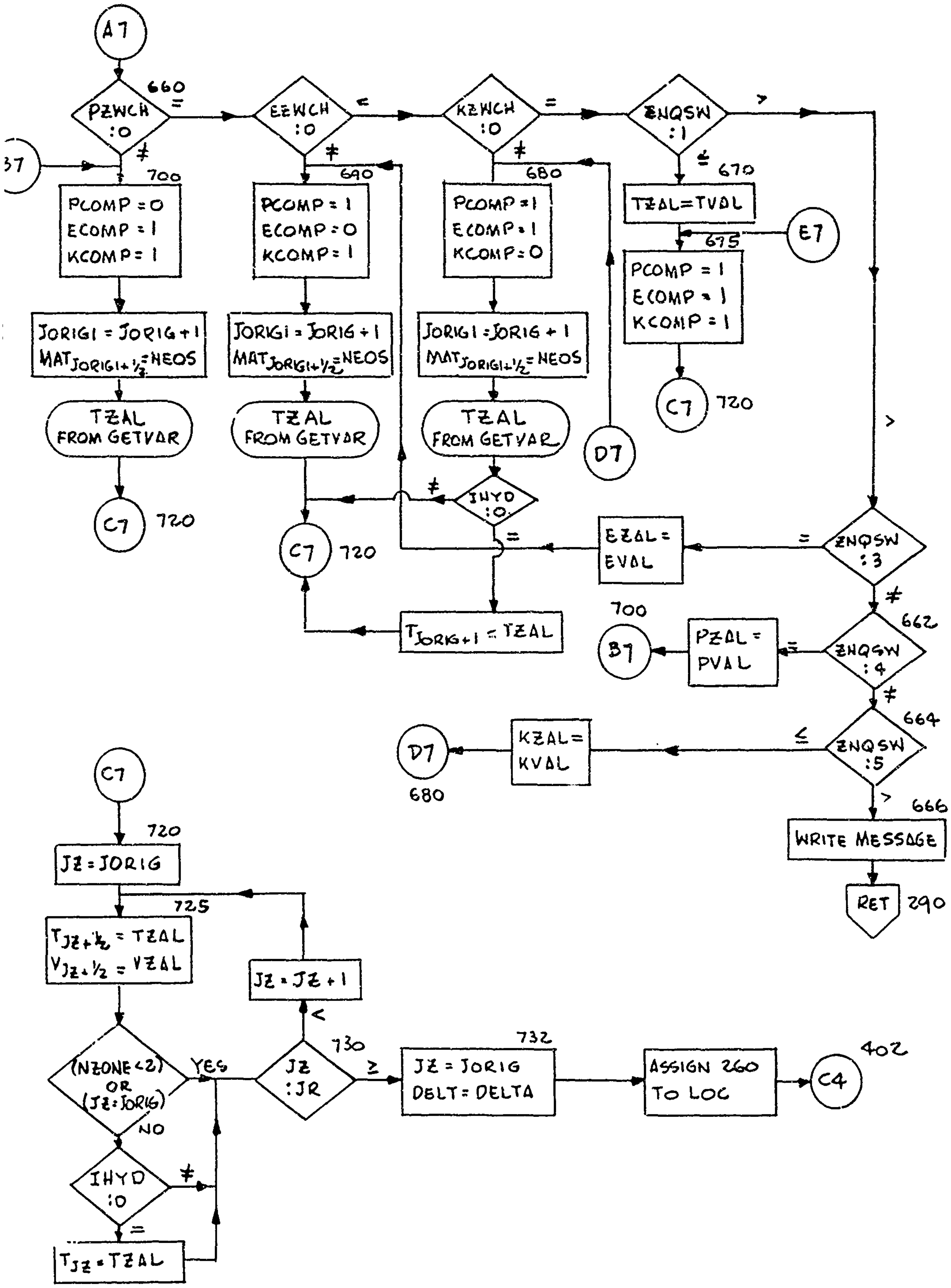

A4
JZ = JL
270
$T_{JZ+1/2}$ = TVAL
JZ : JL
IHYD : 0
T_{JZ} = TVAL
273
JZ : JR-1
JZ = JZ + 1
280
ZNQSW : 0
B4
RET
290
360
JZ = JL
365
$V_{JZ+1/2}$ = VVAL
JZ : JR-1
368
ASSIGN 370 TO LLC
JZ = JZ+1
401
JZ = JL
DELT = DELTA
402
$D = R_{JZ+1} - R_{JZ}$
C4
DELTA :1
403
DELTA :2
$D = D \cdot (R_{JZ+1} + R_{JZ})$
404
$D = D \cdot (R^2_{JZ+1} + R_{JZ+1} \cdot R_{JZ} + R^2_{JZ})$
405
ZNSWC :0
$\Delta M_{JZ+1/2}$ = D/DELT/VZAL
407
JZ : JR
409
$\Delta M_{JZ+1/2}$ = D/DELT/ VVAL
JZ : JR-1
408
JZ = JZ+1
C4
402
406
GO TO LLC
260
B3
370
PCOMP :0
D4
PVAL FROM PEK
380
ECOMP :0
EVAL FROM PEK
390
KCOMP :0
IHYD :0
KVAL FROM PEK
400
ZGETSW :0
RET
290
ZNQSW :0
RET
290
C3
320

ZONG... - 5


A5
420
JR = JORIG + NZONE-1
JZ = JORIG
TZWCH :0
740
A8
MZWCH :0
425
ASSIGN 660 TO LOC
VZWCH :0
RHZWCH :0
440
VZAL = 1/RHZAL
PZWCH :0
450
EZWCH :0
A7
660
460
KZWCH :0
455
TZAL, VZAL FROM GETTV
465
TZAL, VZAL FROM GETTV
PCOMP = 0
ECOMP = 0
KCOMP = 1
PCOMP = 0
ECOMP = 1
KCOMP = 0
C7
720
C7
720
C5
B5
A6
D5
430
DELT = DELTA
DELTA :1
432
DELTA :2
434
D = R_{JZ+1} - R_{JZ}
D = R^2_{JZ+1} - R^2_{JZ}
D = R^3_{JZ+1} - R^3_{JZ}
436
VZAL = D/DELT/DMZAL
675
E7
660
GO TO LOC
290
WRITE MESSAGE
RET
490
VZAL = VVAL
4,6
470
ZNQ SW =
480
TZAL = TVAL
710
JORIGI = JORIG + 1
MAT_{JORIGI+½} = NEOS
VZAL FROM GETVAR
510
KZAL = KVAL
500
EZAL = EVAL
PCOMP = 0
ECOMP = 1
KCOMP = 1
C7
720
520
JZ = JORIG
525
P_{JZ+½} = PZAL
JZ = JZ+1
JZ : JR
RET
290

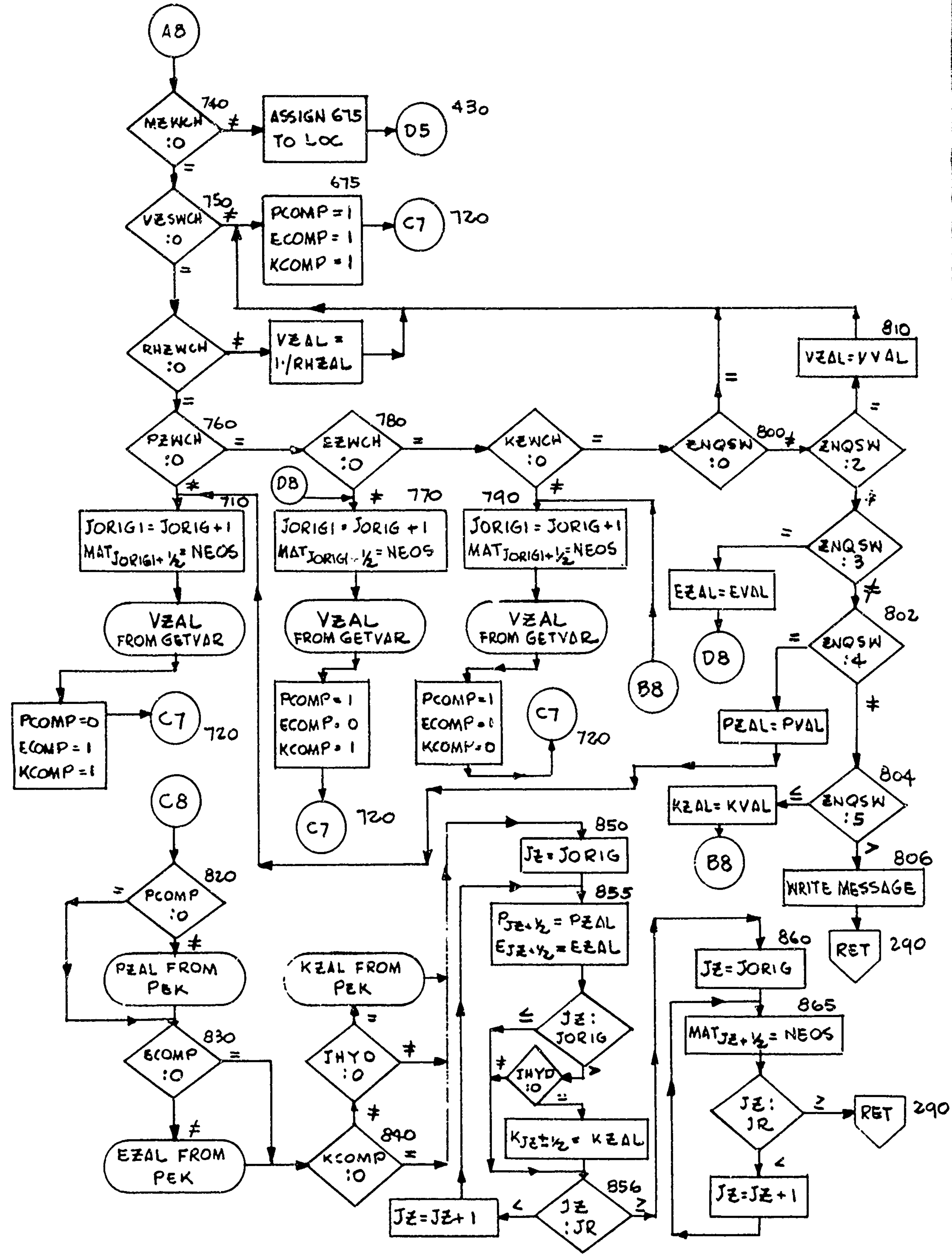
ZONGEN - 6


A6
EZWCH :0
KZWCH :0
530
WRITE MESSAGE
RET
290
3,6
540
ZNQSW =
580
PZAL = PVAL
B5
455
550
JZ = JORIG
555
$E_{JZ+1/2}$ = EZAL
JZ : JR
RET
290
JZ = JZ + 1
B6
535
TZAL, VZAL FROM GETTV
PCOMP = 1
ECOMP = 0
KCOMP = 0
C7
720
560
TZAL = TVAL
DB
770
570
VZAL = VVAL
690
PCOMP = 1
ECOMP = 0
KCOMP = 1
590
KZAL = KVAL
B6
535
VZAL FROM GETVAR
790
JORIG1 = JORIG + 1
$MAT_{JORIG1+1/2}$ = NEOS
PCOMP = 1
ECOMP = 1
KCOMP = 0
C7
720
JORIG1 = JORIG + 1
$MAT_{JORIG1+1/2}$ = NEOS
TZAL FROM GETVAR
720
C7
RET
290
620
TZAL = TVAL
WRITE MESSAGE
630
VZAL = VVAL
680
PCOMP = 1
ECOMP = 1
KCOMP = 0
KZWCH :0
600
ZNQSW =
290
RET
IHYD :0
610
JZ = JORIG
ZNQSW :0
615
$K_{JZ-1/2}$ = KZAL
JZ : JR
JZ = JZ + 1
RET
290
640
EZAL = EVAL
B6
535
650
PZAL = PVAL
C5
465
JORIG1 = JORIG + 1
$MAT_{JORIG1+1/2}$ = NEOS
TZAL FROM GETVAR
IHYD :0
C7
720
$T_{JORIG+1}$ = TZAL
WRITE MESSAGE
290
RET
870
TZAL = TVAL
VZAL = VVAL
C7
720
B7



A7
660
PZWCH :0
EZWCH :0
KZWCH :0
ZNQSW :1
700
PCOMP = 0
ECOMP = 1
KCOMP = 1
690
PCOMP = 1
ECOMP = 0
KCOMP = 1
680
PCOMP = 1
ECOMP = 1
KCOMP = 0
670
TZAL = TVAL
675
E7
PCOMP = 1
ECOMP = 1
KCOMP = 1
JORIG1 = JORIG + 1
MAT JORIG1+1/2 = NEOS
TZAL FROM GETVAR
C7 720
D7
IHYD :0
EZAL = EVAL
ZNQSW :3
T JORIG+1 = TZAL
700
B7
PZAL = PVAL
662
ZNQSW :4
664
ZNQSW :5
KZAL = KVAL
D7
680
666
WRITE MESSAGE
RET 290
C7
720
JZ = JORIG
725
T JZ+1/2 = TZAL
V JZ+1/2 = VZAL
JZ = JZ + 1
(NZONE<2) OR (JZ=JORIG)
YES
NO
730
JZ :JR
732
JZ = JORIG
DELT = DELTA
ASSIGN 260 TO LOC
C4
402
IHYD :0
T JZ = TZAL

ZONGEN - 8


A8
740
MZWCH :0
≠
ASSIGN 675 TO LOC
D5
430
=
675
750
VZSWCH :0
≠
PCOMP = 1
ECOMP = 1
KCOMP = 1
C7
720
=
RHZWCH :0
≠
VZAL = 1./RHZAL
=
810
VZAL=VVAL
760
PZWCH :0
=
780
EZWCH :0
=
KZWCH :0
=
ZNQSW :0
800
≠
ZNQSW :2
=
≠
710
D8
770
790
JORIG1 = JORIG + 1
MAT JORIG1+½ = NEOS
JORIG1 = JORIG + 1
MAT JORIG1-½ = NEOS
JORIG1 = JORIG + 1
MAT JORIG1+½ = NEOS
ZNQSW :3
EZAL=EVAL
D8
802
ZNQSW :4
VZAL FROM GETVAR
VZAL FROM GETVAR
VZAL FROM GETVAR
B8
PCOMP = 0
ECOMP = 1
KCOMP = 1
C7
720
PCOMP = 1
ECOMP = 0
KCOMP = 1
PCOMP = 1
ECOMP = 1
KCOMP = 0
C7
720
PZAL = PVAL
804
KZAL = KVAL
≤
ZNQSW :5
C8
C7
720
B8
850
JZ = JORIG
>
806
WRITE MESSAGE
820
PCOMP :0
=
≠
855
P JZ+½ = PZAL
E JZ+½ = EZAL
RET
290
860
JZ = JORIG
PZAL FROM PEK
KZAL FROM PEK
865
MAT JZ+½ = NEOS
830
ECOMP :0
=
THYD :0
≠
JZ : JORIG
≤
THYD :0
JZ : JR
≥
RET
290
≠
EZAL FROM PEK
≠
840
KCOMP :0
=
K JZ±½ = KZAL
856
<
JZ = JZ + 1
JZ : JR
≥
<
JZ = JZ + 1

18. PEK(NQ,MA,TP,VP,J,ND,F,C)

PEK calculates F(TP, VP) or $\frac{\partial F}{\partial TP}$ or $\frac{\partial F}{\partial VP}$ in a zone. The arguments in the calling sequence are:

NQ: 1 if F is pressure
2 if F is energy
3 if F is opacity

MA: the material number of the zone in question

TP: the temperature

VP: the specific volume

J: the number of the zone

ND: 0 if F(T,V) is desired
1 if $\frac{\partial F(T,V)}{\partial TP}$ is desired
2 if $\frac{\partial F(T,V)}{\partial VP}$ is desired

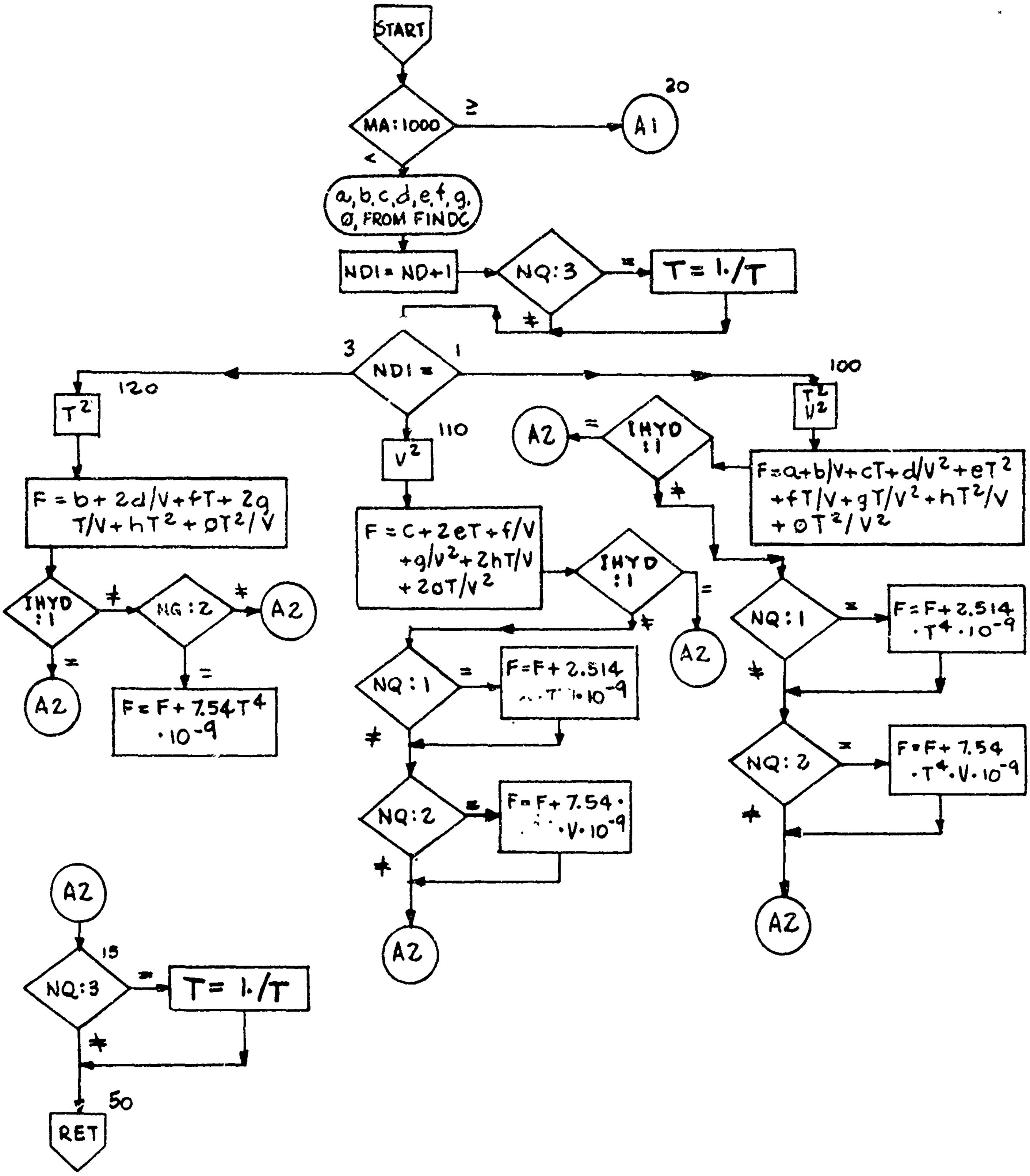
F: the variable to be returned

C. the coefficient table

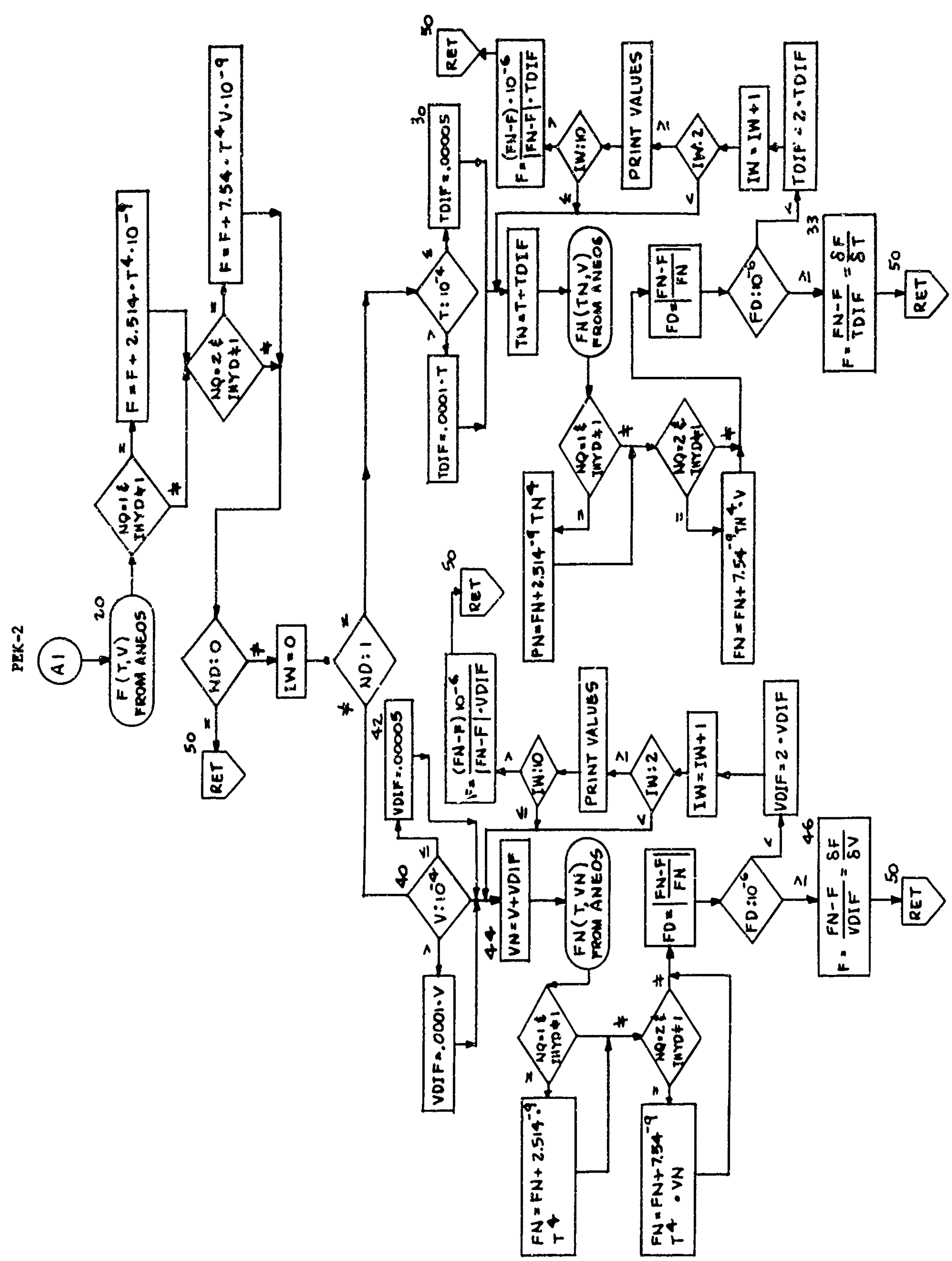
```
$IBFTC PEKG
      SUBROUTINE PEK(NQ,MA,TP,VP,J,ND,F,C)
C     COMMON CARD  LABFLED /IKAIA/ GROUP TO BE PLACED HERE
       DIMENSION COE(9)
       DIMENSION C(1)
      IF (MA.GE.1000) GO TO 20
      CALL FINDC(NQ,MA,TP,VP,COE,C)
      ND1=ND+1
C
C     TRANSFER TO FIND FUNCTION, DERIV W.R.T. T OR DERIV W.R.T. V RESPT.
C
       IF (NQ.EQ.3) TP=1./TP
       GO TO (100,110,120),ND1
  100 T2=TP*TP
      V2=VP*VP
       F=COE(1)+COE(2)/VP+COE(3)*TP+COE(4)/V2+COE(5)*T2+COE(6)*TP/VP+
     1 COE(7)*TP/V2+COE(8)*T2/VP+COE(9)*T2/V2
       IF (IHYD.EQ.1) GO TO 15
       IF(NQ.EQ.1) F=F+2.514*TP**4*1.E-9
       IF(NQ.EQ.2) F=F+7.54*TP**4*VP*1.E-9
       GO TO 15
  110 V2=VP*VP
       F=COE(3)+COE(5)*2.*TP+COE(6)/VP+COE(7)/V2+COE(8)*2.*TP/VP+
     1 COE(9)*2.*TP/V2
       IF (IHYD.EQ.1) GO TO 15
       IF(NQ.EQ.1) F=F+2.514*TP**3*4.E-9
       IF(NQ.EQ.2) F=F+7.54*TP**3*VP*4.E-9
       GO TO 15
```

```
  120 T2=TP*TP
      F= COE(2)+COE(4)*2./VP+COE(6)*TP+COE(7)*2.*TP/VP+COE(8)*T2+
     1 COE(9)*2.*T2/VP
       IF (IHYD.EQ.1) GO TO 15
       IF(NQ.EQ.2) F=F+7.54*TP**4*1.E-9
 15    IF (NQ.EQ.3) TP= 1./TP
      GO TO 50
 1005 FORMAT (32H0 PEKG FRMT1005      ND IS WRONG. )
   20 CALL ANEOS (NQ,MA,TP,VP,F)
      IF (NQ.EQ.1.AND.IHYD.NE.1) F=F+2.514E-9*TP**4
      IF (NQ.EQ.2.AND.IHYD.NE.1) F=F+7.54E-9*TP**4*VP
      IF (ND.EQ.0) GO TO 50
       IW=0
      IF (ND.NE.1) GO TO 40
      IF (TP.LE.0.0001 ) GO TO 30
      TDIF=TP*.0001
      GO TO 32
   30 TDIF=.00005
   32 TN=TP+TDIF
      CALL ANEOS (NQ,MA,TN,VP,FN)
      IF (NQ.EQ.1.AND.IHYD.NE.1) FN=FN+2.514E-9*TN**4
      IF (NQ.EQ.2.AND.IHYD.NE.1) FN=FN+7.54E-9*TN**4*VP
      FD=ABS((FN-F)/FN)
      IF (FD.GE.1.E-06) GO TO 33
      TDIF=2.*TDIF
       IW=IW+1
       IF(IW.LT.2) GO TO 32
       PRINT 2000, J,NQ,ND,IW,TP,TDIF,TN,F,FN,FD
 2000  FORMAT (4I6,6E16.8)
       IF (IW.LE.10) GO TO 32
       F=(FN-F)*1.E-06/ABS(FN-F)/TDIF
       GO TO 50
 33   F= (FN-F)/TDIF
      GO TO 50
   40 IF (VP.LE.0.0001 ) GO TO 42
      VDIF=VP*.0001
      GO TO 44
   42 VDIF=.00005
   44 VN=VP+VDIF
      CALL ANEOS (NQ,MA,TP,VN,FN)
      IF (NQ.EQ.1.AND.IHYD.NE.1) FN=FN+2.514E-9*TP**4
      IF (NQ.EQ.2.AND.IHYD.NE.1) FN=FN+7.54E-9*TP**4*VN
      FD=ABS((FN-F)/FN)
      IF (FD.GE.1.E-06) GO TO 46
      VDIF=2.*VDIF
       IW=IW+1
       IF(IW.LT.2) GO TO 44
       PRINT 2000,J,NQ,ND,IW,TP,VDIF,VN,F,FN,FD
       IF (IW.LE.10) GO TO 44
       F=(FN-F)*1.E-06/ABS(FN-F)/VDIF
       GO TO 50
 46    F = (FN-F)/VDIF
   50 RETURN
      END
```

PRK - 1


START
MA:1000
A1
20
a, b, c, d, e, f, g, ∅, FROM FINDC
NDI = ND+1
NQ:3
T = 1./T
NDI =
120
110
100
T²
V²
F = b + 2d/V + fT + 2g T/V + hT² + ∅T²/V
F = c + 2eT + f/V + g/V² + 2hT/V + 2∅T/V²
F = a + b/V + cT + d/V² + eT² + fT/V + gT/V² + hT²/V + ∅T²/V²
IHYD :1
NQ:2
NQ:1
A2
F = F + 7.54T⁴ ·10⁻⁹
F = F + 2.514 ·T⁴·10⁻⁹
F = F + 7.54 ·T⁴·V·10⁻⁹
15
50
RET

PEK-2


A1
F (T,V) FROM ANEOS
NO=1 & INYD≠1
F = F + 2.514 · T4 · 10-9
NO=2 & INYD≠1
F = F + 7.54 · T4 V · 10-9
ND:0
RET
IW = 0
ND:1
T:10-4
TDIF = .0001 · T
TDIF = .00005
TN = T + TDIF
FN (TN,V) FROM ANEOS
FN = FN + 2.514-9 TN4
FN = FN + 7.54-9 TN4 · V
FD = |FN-F / FN|
FD:10-6
F = FN-F / TDIF = δF / δT
IW:2
IW = IW + 1
TDIF = 2 · TDIF
PRINT VALUES
IW:10
F = (FN-F) · 10-6 / |FN-F| · TDIF
V:10-4
VDIF = .0001 · V
VDIF = .00005
VN = V + VDIF
FN (T,VN) FROM ANEOS
FN = FN + 2.514-9 T4
FN = FN + 7.54-9 T4 · VN
F = FN-F / VDIF = δF / δV
VDIF = 2 · VDIF
F = (FN-F) 10-6 / |FN-F| · VDIF

19. FINDC(NF,MA,TP,VP,F,C)

FINDC obtains the coefficients for the macro-box defined by TP and VP and returns them in F. The parameters are:

NF: 1 for pressure
2 for energy
3 for opacity

MA: material of zone

TP: temperature

VP: specific volume

F: a, b, c, d, e, f, g, h, o are returned in F_{1-9}.

C: the table of T's, ρ's and coefficients

LIMIT: number of C's

For a description of the form of the coefficient table, etc., see paragraph 13.

```
$IBFTC FINDC   REF
      SUBROUTINE FINDC (NF,MA,TP,VP,F,C)
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
       DIMENSION F(9), C(1)
      MA1=MA+1
      LOOK = IDEOS(MA1)
      IF(LOOK.NE. 0)  GO TO 5
    2 PRINT 7001,MA
 7001 FORMAT (34H1 FINDC FRMT7001    MATERIAL NO. = I4,12H IS NOT USED
     1 13H IN THIS JOB. )
      RETURN
    5 DO 6 I=1,6
      IF(IORDER(I).EQ.LOOK) GO TO 9
    6 CONTINUE
       GO TO 2
    9 MA1 =I
      ITABT=0
      L1= IBEGT(NF,MA1)
      L2= IBEGV(NF,MA1)-1
       IF(NF.EQ.3) TP= 1./TP
      DO 7 I=L1,L2,2
       IF((TP.GE.C(I).AND.TP.LE.C(I+2)).OR.(TP.LE.C(I).AND.TP.GE.C(I+2))
     1 ) GO TO 10
      ITABT= ITABT+1
    7 CONTINUE
 10    IF(NF.EQ.3) TP= 1./TP
       ITABV=0
      L1= IBEGV(NF,MA1)
      L2= IBEGC(NF ,MA1)-1
```

```
      VP=1./VP
      DO 13 I=L1,L2,2
      IF((VP.GE.C(I).AND.VP.LE.C(I+2)).OR.(VP.LE.C(I).AND.VP.GE.C(I+2
     1 ) GO TO 15
      ITABV=ITABV+1
   13 CONTINUE
   15 NOFT = (IBEGV(NF,MA1)-IBEGT(NF,MA1))/2
      ICSUB = IBEGC(NF,MA1)+ ITABV*NOFT*9+ITABT*9-1
      DO 20 I=1,9
      ISUB =ICSUB+I
   20 F(I)= C(ISUB)
      VP=1./VP
      RETURN
      END
```

20. ANEOS(NF,MA,TP,VP,F)

ANEOS calculates F(TP, VP) for materials with analytic equations of state. MA is a number between 1000-1005 inclusive. ANEOS calls the function type subroutines FP100x, FE100x or FK100x where 100x is the material number. The arguments are:

NF: 1 for pressure

2 for energy

3 for opacity

MA: material in the zone

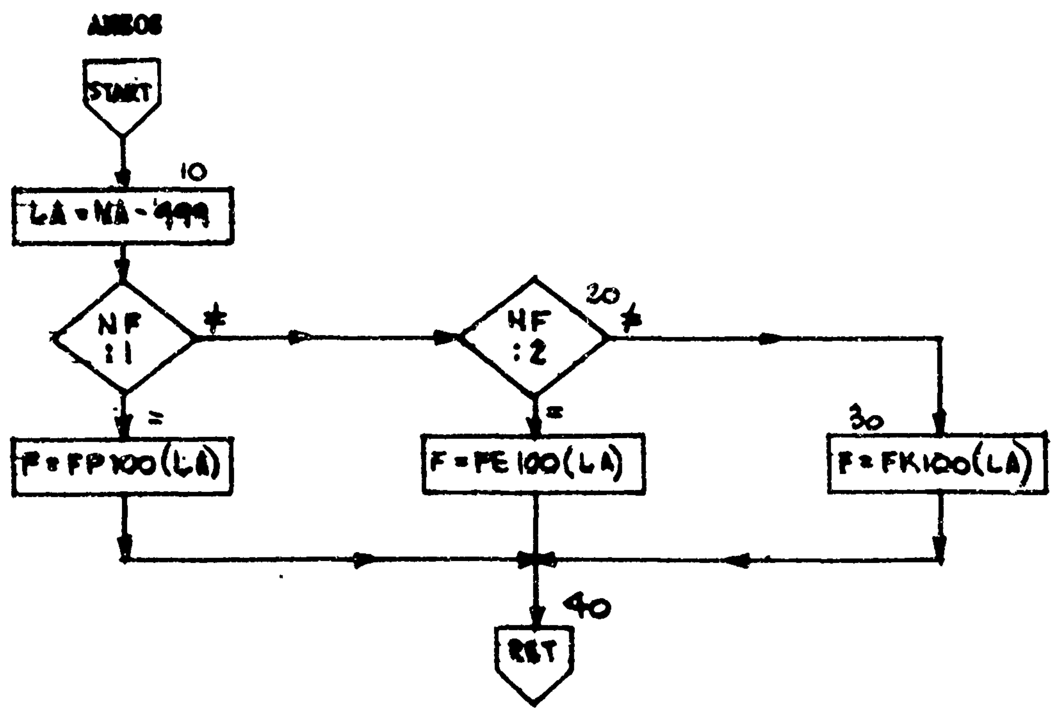
TP: temperature

VP: specific volume

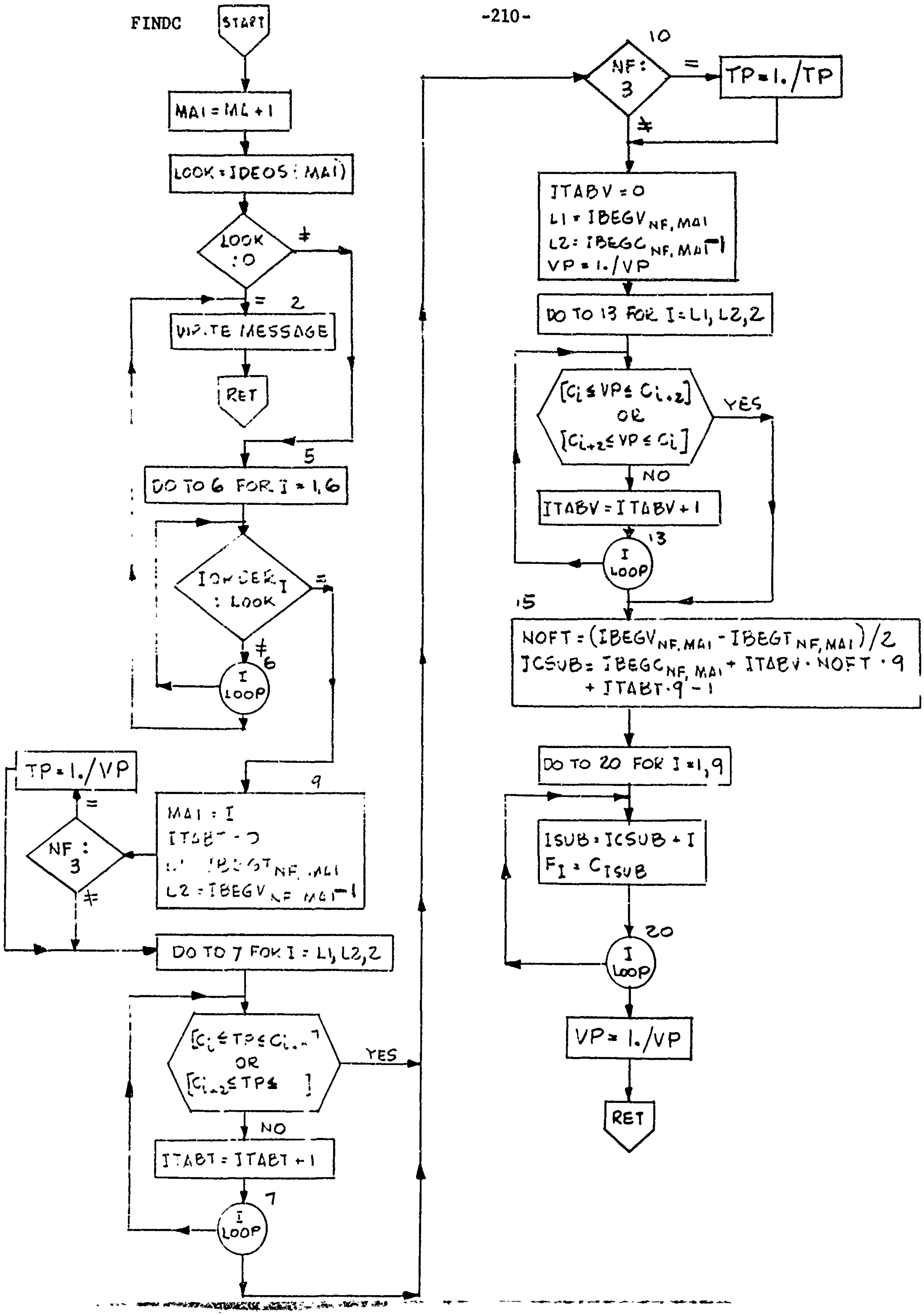
F: F(TP, VP) is returned here.

```
$IBFTC ANEOS   REF
      SUBROUTINE ANEOS (NF,MA,TP,VP,F)
   10 LA=MA-999
      IF (NF.NE.1) GO TO 20
      GO TO (11,12,13,14,15,16),LA
   11 F =  FP1000 (TP,VP)
      GO TO 40
   12 F=   FP1001 (TP,VP)
      GO TO 40
   13 F =  FP1002  (TP,VP)
      GO TO 40
   14 F =  FP1003 (TP,VP)
      GO TO 40
   15 F =  FP1004 (TP,VP)
      GO TO 40
   16 F =  FP1005 (TP,VP)
      GO TO 40
```

```
20 IF (NF.NE.2) GO TO 30
   GO TO (21,22,23,24,25,26),LA
21 F = FE1000(TP,VP)
   GO TO 40
22 F= FE1001(TP,VP)
   GO TO 40
23 F= FE1002 (TP,VP)
   GO TO 40
24 F = FE1003 (TP,VP)
   GO TO 40
25 F = FE1004 (TP,VP)
   GO  TO 40
26 F = FE1005 (TP,VP)
   GO TO 40
30 GO TO (31,32,33,34,35,36),LA
31 F =FK1000(TP,VP)
   GO TO 40
32 F= FK1001(TP,VP)
   GO TO 40
33 F = FK1002(TP,VP)
   GO TO 40
34 F= FK1003(TP,VP)
   GO TO 40
35 F = FK1004 (TP,VP)
   GO TO 40
36 F = FK1005 (TP,VP)
40 RETURN
   END
```



FINDC


START
MAI = ML + 1
LOOK = IDEOS (MAI)
LOOK : 0
WRITE MESSAGE
RET
DO TO 6 FOR I = 1, 6
I LOOP
MAI = I
L2 = IBEGV NF, MAI - 1
NF : 3
TP = 1./VP
DO TO 7 FOR I = L1, L2, 2
YES
NO
OR
ITABT = ITABT + 1
I LOOP
NF : 3
TP = 1./TP
ITABV = 0
L1 = IBEGV NF, MAI
L2 = IBEGC NF, MAI - 1
VP = 1./VP
DO TO 13 FOR I = L1, L2, 2
[Ci ≤ VP ≤ Ci+2]
OR
[Ci+2 ≤ VP ≤ Ci]
YES
NO
ITABV = ITABV + 1
I LOOP
NOFT = (IBEGV NF, MAI - IBEGT NF, MAI)/2
ICSUB = IBEGC NF, MAI + ITABV · NOFT · 9
+ ITABT · 9 - 1
DO TO 20 FOR I = 1, 9
ISUB = ICSUB + I
FI = CISUB
I LOOP
VP = 1./VP
RET

21. FP100x(T,V)

FP100x is a function type subroutine which calculates P(T,V) or P(E,V) for material 100x. x must be between 0 and 5 inclusive.

22. FE100x(T,V)

FE100x is a function type subroutine which calculates E(T,V) or T(E,V) for material 100x.

23. FK100x(T,V)

FK100x is a function type subroutine which calculates K(T,V) for material 100x.

24. GETVAR(MF,NV,F,VAR,JV,OVAR,C)

GETVAR has as input a dependent variable P, E or K and an independent variable of T or V. It returns the other independent variable. The arguments are:

MF: 1 if P is the dependent variable
2 if E is the dependent variable
3 if K is the dependent variable

NV: 1 if T is the independent variable
2 if V is the independent variable

F: the value of the dependent variable

VAR: the value of the independent variable

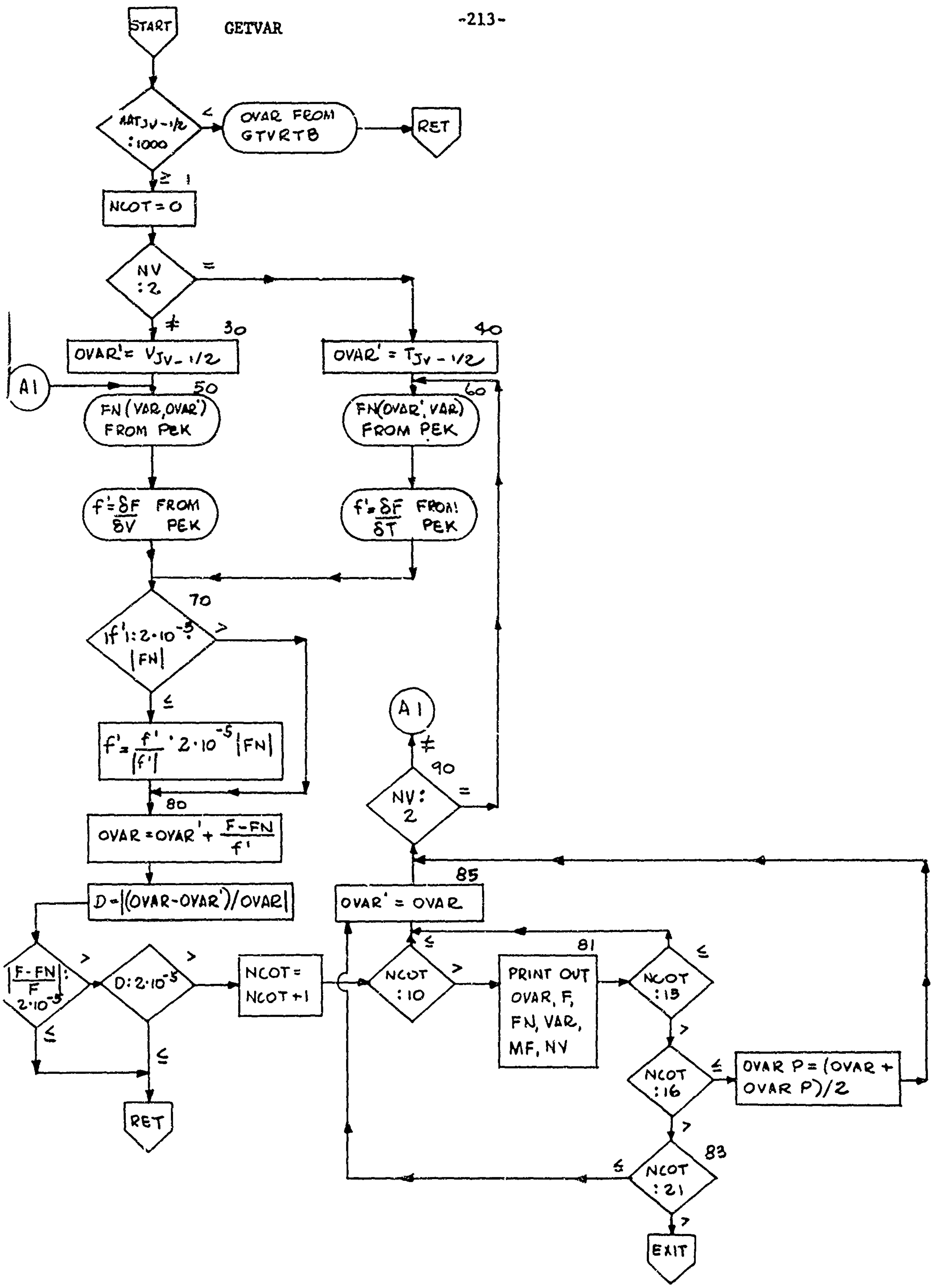
JV: the zone number

OVAR: the other independent variable will be returned here.

C: the coefficient table

```
$IBFTC GTVARG
      SUBROUTINE GETVAR (MF,NV,F,VAR,JV,OVAR,C)
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
```

```
      COMMON /TEMC/ TEM(1)
      COMMON /VLC/ VL(1)
      COMMON /MATC/ MAT(1)
       DIMENSION C(1)
      IF(MAT(JV+1).GE.1000) GO TO 1
      CALL GTVRTB(MF,NV,F,VAR,JV,OVAR,MAT(JV+1),C)
      RETURN
    1 NCOT=0
      IF (NV.EQ.2) GO TO 40
   30 OVARP=VL(JV+1)
      GO TO 50
   40 OVARP=TEM(JV+1)
      GO TO 60
   50 CALL PEK (MF,MAT(JV+1),VAR,OVARP,JV,0,FN,C)
      CALL PEK (MF,MAT(JV+1),VAR,OVARP,JV,2,FP,C)
      GO TO 70
   60 CALL PEK (MF,MAT(JV+1),OVARP,VAR,JV,0,FN,C)
      CALL PEK (MF,MAT(JV+1),OVARP,VAR,JV,1,FP,C)
   70 IF (ABS (FP).GT.2.0E-05*ABS(FN)) GO TO 80
      FP=(FP/ABS(FP))*2.0E-5*ABS(FN)
   80 OVAR=OVARP+(F-FN)/FP
      D= ABS((OVAR-OVARP)/OVAR)
      IF (ABS((F-FN)/F).LE.2.E-5) RETURN
      IF(D.LE.2.E-5) RETURN
      NCOT=NCOT+1
      IF (NCOT.LE.10) GO TO 85
81    WRITE (6,1010) OVAR,F,FN,VAR,MF,NV
1010  FORMAT (25H0 GTVARG FRMT1010    OVAR= E14.6,5H   F= E14.6,6H   FI
     1 E14.6,//8H    VAR= E14.6,6H   MF= I6,6H   NV= I6 )
      IF (NCOT.LE.15) GO TO 85
      IF (NCOT.GT.16) GO TO 83
      OVARP=(OVAR+OVARP)/2.
      GO TO 90
   83 IF (NCOT.LE.21) GO TO 85
       CALL EXIT
85    OVARP=OVAR
   90  IF(NV.EQ.2) GO TO 60
       GO TO 50
      END
```


START
GETVAR
OVAR FROM GTVRTB
RET
NCOT = 0
NV :2
OVAR' = V
OVAR' = T
A1
FN (VAR, OVAR') FROM PEK
FN(OVAR', VAR) FROM PEK
f' = δF/δV FROM PEK
f' = δF/δT FROM PEK
f' = f'/|f'| · 2·10^-5 |FN|
OVAR = OVAR' + (F-FN)/f'
D = |(OVAR-OVAR')/OVAR|
D: 2·10^-5
NCOT = NCOT + 1
RET
OVAR' = OVAR
NV: 2
NCOT :10
PRINT OUT OVAR, F, FN, VAR, MF, NV
NCOT :13
NCOT :16
OVAR P = (OVAR + OVAR P)/2
NCOT :21
EXIT

25. GTVRTB(MF,NV,F,VAR,JV,OVAR,MA,C)

GTVRTB is called by GETVAR if the equation of state is tabular. The calling sequence is the same as for GETVAR. C is the coefficient table. See REOST paragraph 13.

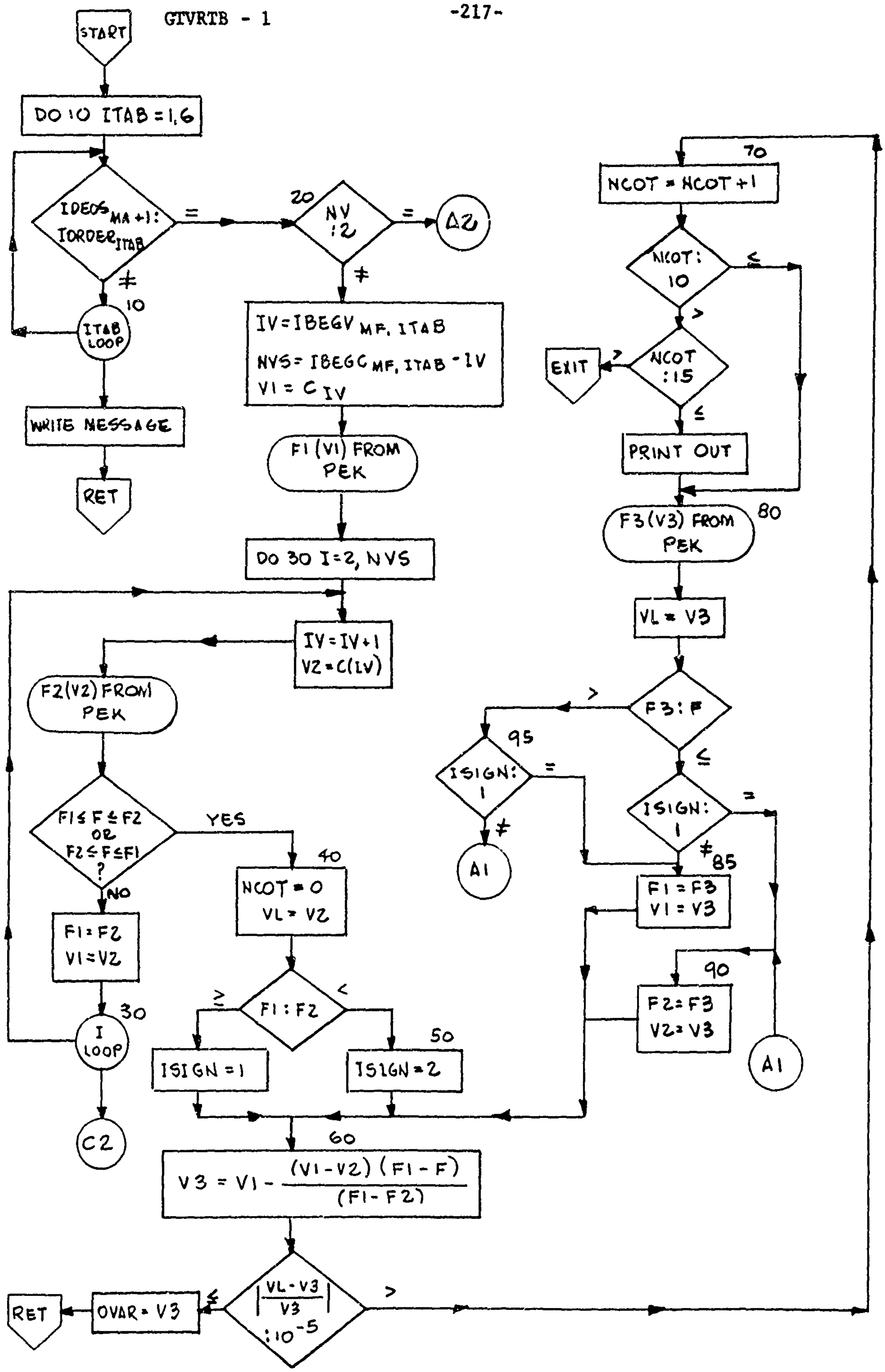
With tabular equations of state a simple Newton Method is difficult to apply since our first guess at the independent variable may not be in the right macro-box, and the coefficients for a macro-box do not necessarily yield derivatives which reflect the shape of the entire surface.

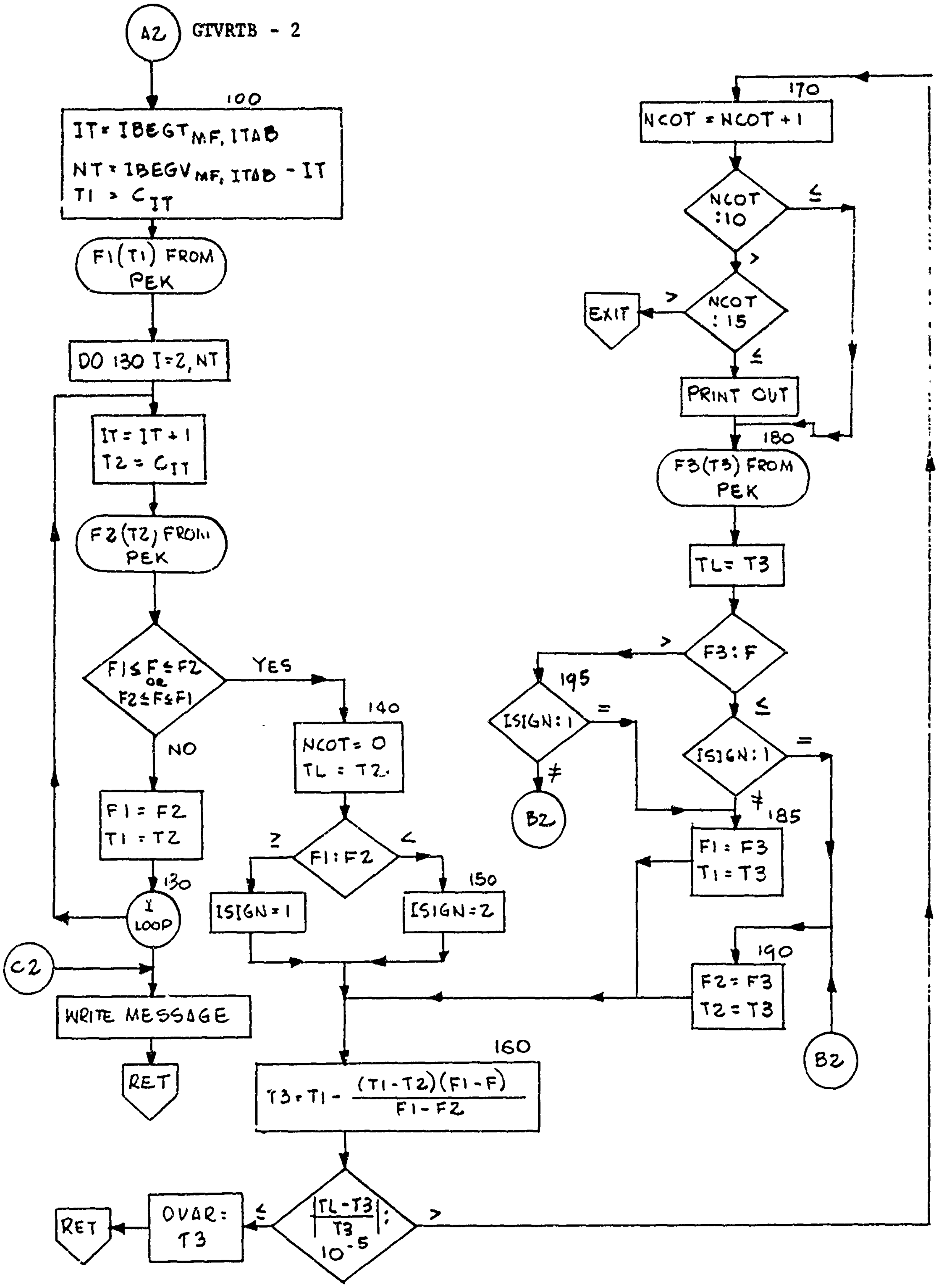
Suppose P and T are given and V is desired. The T specifies a row of macro-boxes in which the P, T, V triplet must lie. In the Generator section of HAROLD we calculate P(T,V) for the given T and for each V sequentially until the given value of P is spanned. At this point we are in the correct macro-box and the regula-falsi method of interpolation is applied to find the solution while making certain that we remain in the macro-box.

```
$IBFTC GVRTBG
      SUBROUTINE GTVRTB(MF,NV,F,VAR,JV,OVAR,MA,C)
     COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
    1 IBEGV(3,6), IBEGC(3,6)
      DIMENSION F(9), C(1)
      DO 10 ITAB=1,6
      IF(IDEOS(MA+1).EQ.IORDER(ITAB)) GO TO 20
   10 CONTINUE
      PRINT 7000
 7000 FORMAT (33H0 GVRTBG FRMT7000 ILLEGAL EOS NO. )
     RETURN
   20 IF(NV.EQ.2) GO TO 100
      IV=IBEGV(MF,ITAB)
      NVS=IBEGC(MF,ITAB)-IV
      V1=C(IV)
      CALL PEK(MF,MA,VAR,V1,JV,0,F1,C)
      DO 30 I=2,NVS
      IV=IV+1
      V2=C(IV)
      CALL PEK(MF,MA,VAR,V2,JV,0,F2,C)
      IF(((F1.GE.F).AND.(F2.LE.F)).OR.((F1.LE.F).AND.(F2.GE.F)))GOT(
      F1=F2
      V1=V2
   30 CONTINUE
      PRINT 7001
 7001 FORMAT (50H0 GVRTBG FRMT7001   UNABLE TO SPAN FUNCTION VALUE. )
     RETURN
```

```
40   NCOT=0
     VL=V2
     IF(F1.LT.F2) GO TO 50
     ISGN=1
     GO TO 60
50   ISGN=2
60   V3=V1-(V1-V2)*(F1-F)/(F1-F2)
     IF(ABS((VL-V3)/V3).GT.1.E-5) GO TO 70
     OVAR=V3
     RETURN
70   NCOT=NCOT+1
     IF(NCOT.LE.10) GO TO 80
     IF(NCOT.GT.15) CALL EXIT
     PRINT 7002, V1,V2,V3,F1,F2,F3
7002 FORMAT (42H0 GVRTBG FRMT7002   V1, V2, V3, F1, F2, F3 /6E16.7 )
80   CALL PEK(MF,MA,VAR,V3,JV,0,F3,C)
     VL=V3
     IF(F3.GT.F) GO TO 95
     IF(ISGN.EQ.1) GO TO 90
85   F1=F3
     V1=V3
     GO TO 60
90   F2=F3
     V2=V3
     GO TO 60
95   IF(ISGN.EQ.1) GO TO 85
     GO TO 90
100  IT=IBEGT(MF,ITAB)
     NT=IBEGV(MF,ITAB)-IT
     T1=C(IT)
     CALL PEK(MF,MA,T1,VAR,JV,0,F1,C)
     DO130 I=2,NT
     IT=IT+1
     T2=C(IT)
     CALL PEK(MF,MA,T2,VAR,JV,0,F2,C)
     IF(((F1.GE.F).AND.(F2.LE.F)).OR.((F1.LE.F).AND.(F2.GE.F)))GOTO140
     F1=F2
     T1=T2
130  CONTINUE
     PRINT 7001
     RETURN
140  NCOT=0
     TL=T2
     IF(F1.LT.F2) GO TO 150
     ISGN=1
     GO TO 160
150  ISGN=2
160  T3=T1-(T1-T2)*(F1-F)/(F1-F2)
     IF( ?S((TL-T3)/T3).GT.1.E-5) GO TO170
     OVAR=T3
     RETURN
```

```
 170  NCOT=NCOT+1
      IF(NCOT.LE.10) GO TO 180
      IF(NCOT.GT.15) CALL EXIT
      PRINT 7003, T1,T2,T3,F1,F2,F3
7003 FORMAT (42H0 GVRTBG FRMT7003   T1, T2, T0, F1, F2, F3 /6E16.7 )
 180  CALL PEK(MF,MA,T3,VAR,JV,0,F3,C)
      TL=T3
      IF(F3.GT.F) GO TO 195
      IF(ISGN.EQ.1) GO TO 190
 185  F1=F3
      T1=T3
      GO TO 160
 190  T2=T3
      F2=F3
      GO TO 160
 195  IF(ISGN.EQ.1) GO TO 185
      GO TO 190
      END
```


START
DO 10 ITAB = 1,6
IDEOS MA+1 : IORDER ITAB
=
≠
10
ITAB LOOP
WRITE MESSAGE
RET
20
NV :2
=
Δ2
≠
IV = IBEGV MF, ITAB
NVS = IBEGC MF, ITAB - IV
V1 = C IV
F1 (V1) FROM PEK
DO 30 I=2, NVS
IV = IV+1
V2 = C(IV)
F2(V2) FROM PEK
F1 ≤ F ≤ F2 OR F2 ≤ F ≤ F1 ?
YES
NO
F1 = F2
V1 = V2
30
I LOOP
C2
40
NCOT = 0
VL = V2
F1 : F2
≥
<
ISIGN = 1
50
ISIGN = 2
60
V3 = V1 - (V1-V2)(F1-F)/(F1-F2)
|VL-V3 / V3| : 10^-5
≤
>
OVAR = V3
RET
70
NCOT = NCOT + 1
NCOT : 10
≤
>
NCOT : 15
>
EXIT
≤
PRINT OUT
80
F3(V3) FROM PEK
VL = V3
F3 : F
>
≤
95
ISIGN : 1
=
≠
A1
ISIGN : 1
=
≠
85
F1 = F3
V1 = V3
90
F2 = F3
V2 = V3
A1


A2
GTVRTB - 2
100
IT = IBEGT MF, ITAB
NT = IBEGV MF, ITAB - IT
T1 = C IT
F1(T1) FROM PEK
DO 130 I=2, NT
IT = IT + 1
T2 = C IT
F2(T2) FROM PEK
F1≤F≤F2 OR F2≤F≤F1
YES
NO
F1 = F2
T1 = T2
130
I LOOP
C2
WRITE MESSAGE
RET
140
NCOT = 0
TL = T2
F1:F2
≥
<
ISIGN = 1
150
ISIGN = 2
160
T3 = T1 - (T1-T2)(F1-F)/(F1-F2)
|TL-T3|/T3 : 10^-5
≤
>
OVAR: T3
RET
170
NCOT = NCOT + 1
NCOT :10
≤
>
NCOT : 15
>
EXIT
≤
PRINT OUT
180
F3(T3) FROM PEK
TL = T3
F3 : F
>
≤
195
ISIGN : 1
=
≠
B2
ISIGN : 1
=
≠
185
F1 = F3
T1 = T3
190
F2 = F3
T2 = T3
B2

26. GETTV(NF1,NF2,JV,F1,F2,TN,VN)

GETTV has as input two dependent variables and returns the two independent variables. The Newton-Raphson method is used.

NF1: 1 if F1 is P
     2 if F1 is E
     3 if F1 is K

NF2: same for F2

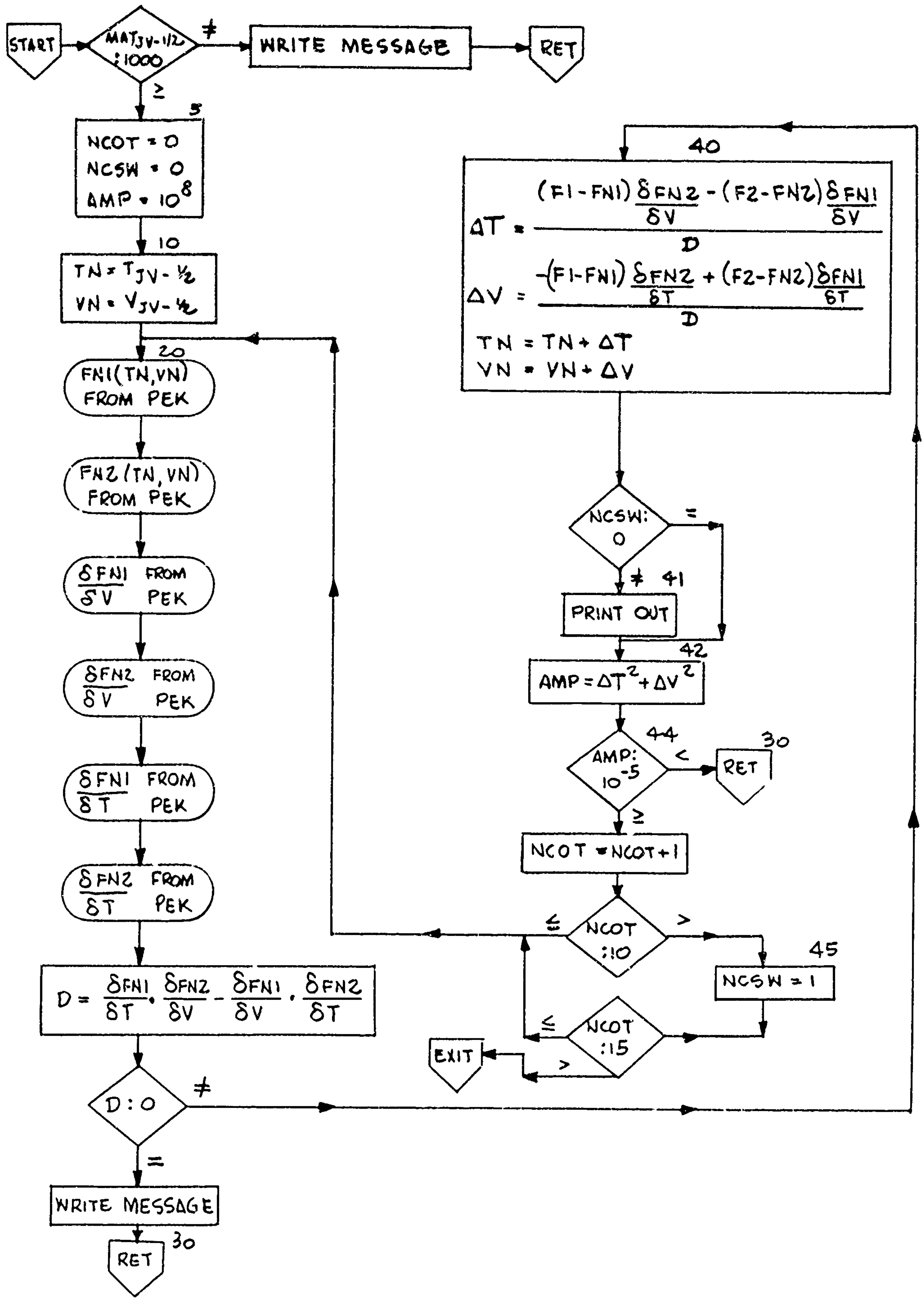
JV: zone number

F1 and F2: dependent variables

TN and VN: independent variables

```
$IBFTC GETTV    REF
      SUBROUTINE GETTV (NF1,NF2,JV,F1,F2,TN,VN)
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      COMMON /TEMC/ TEM(1)
      COMMON /VLC/ VL(1)
      COMMON /MATC/ MAT(1)
       IF(MAT(JV+1).GE.1000) GO TO 5
       WRITE (6,1001)
 1001  FORMAT(30H0GETTV CALLED FOR TABULAR EOS.  )
       RETURN
    5 NCOT=0
      NCSW=0
      AMP=1.E+8
   10 TN=TEM(JV+1)
      VN=VL(JV+1)
   20 CALL PEK (NF1,MAT(JV+1),TN,VN,JV,0,FN1,C)
      CALL PEK (NF2,MAT(JV+1),TN,VN,JV,0,FN2,C)
      CALL PEK (NF1,MAT(JV+1),TN,VN,JV,2,FN1V,C)
      CALL PEK (NF2,MAT(JV+1),TN,VN,JV,2,FN2V,C)
      CALL PEK (NF1,MAT(JV+1),TN,VN,JV,1,FN1T,C)
      CALL PEK (NF2,MAT(JV+1),TN,VN,JV,1,FN2T,C)
      D= FN1T*FN2V-FN1V*FN2T
      IF (D.NE.0.) GO TO 40
      ERFLAG=1
      WRITE (6,1000)
 1000 FORMAT (1H0,36H ****** ERROR IN GETTV--JACOBIAN=0. )
   30 RETURN
   40 TDIF=((F1-FN1)*FN2V-(F2-FN2)*FN1V )/D
      VDIF= (-(F1-FN1)*FN2T +(F2-FN2)*FN1T )/D
      TN=TN+TDIF
      VN=VN+VDIF
      IF (NCSW.EQ.0) GO TO 42
 41   WRITE (6,1005) TN,VN,TDIF,VDIF,FN1,FN2
 1005 FORMAT (1H0,3X,3HTN=E14.6,3X,3HVN=E14.6,3X,5HTDIF=E14.6,3X,5HVDIF=
     1 E14.6/ 1H ,3X,4HFN1=E14.6,3X,4HFN2=E14.6)
 42   AMP =TDIF**2+VDIF**2
   44 IF (AMP .LT.1.E-05) GO TO 30
      NCOT=NCOT+1
      IF (NCOT.GT. 10) GO TO 45
      GO TO 20
 45   NCSW=1
      IF (NCOT.GT.15) CALL EXIT
      GO TO 20
      END
```

GETTV


START
MATJV-1/2 : 1000
≠
WRITE MESSAGE
RET
≥
5
NCOT = 0
NCSW = 0
AMP = 10^8
10
TN = TJV-1/2
VN = VJV-1/2
20
FN1(TN,VN) FROM PEK
FN2(TN,VN) FROM PEK
δFN1/δV FROM PEK
δFN2/δV FROM PEK
δFN1/δT FROM PEK
δFN2/δT FROM PEK
D = δFN1/δT · δFN2/δV − δFN1/δV · δFN2/δT
D : 0
≠
=
WRITE MESSAGE
RET
30
40
ΔT = [(F1−FN1) δFN2/δV − (F2−FN2) δFN1/δV] / D
ΔV = [−(F1−FN1) δFN2/δT + (F2−FN2) δFN1/δT] / D
TN = TN + ΔT
VN = VN + ΔV
NCSW: 0
=
≠
41
PRINT OUT
42
AMP = ΔT² + ΔV²
44
AMP: 10^-5
<
30
RET
≥
NCOT = NCOT+1
NCOT :10
≤
>
45
NCSW = 1
NCOT :15
≤
>
EXIT

27. SOURCE

SOURCE is called by GENRAT. It reads and interprets the RSOURCE and ZSOURCE cards.

IZ is index from 1 to 10 denoting the number of the zone source

JS(IZ) is the zone into which the IZth source is going

NZS(IZ) the number of steps in the IZth source

NZSRCE the total number of source step functions or IZ_{MAX}

EZS(KS,IZ),TMS(KS,IZ) the Kth step of the IZth source

IR is the index from 1 to 10 denoting the number of the region source

RS(IR) the region into which the IRth source is going

$\left.\begin{array}{l}\text{NRS(IR)}\\ \text{NRSRCE)}\end{array}\right\}$ comparable to $\left\{\begin{array}{l}\text{NZS(IZ)}\\ \text{NZSRCE}\end{array}\right.$

ERS(KS,IR),TMRS(KS,IR)} { EZS(KS,IZ),TMS(KS,IZ)

There are a maximum of 10 source functions for zones and regions. If, for example, you had a 12 region problem you could put sources in, at most, 10 of the regions. You could also put sources in 10 zones.

IR_{MAX} and IZ_{MAX} = 10

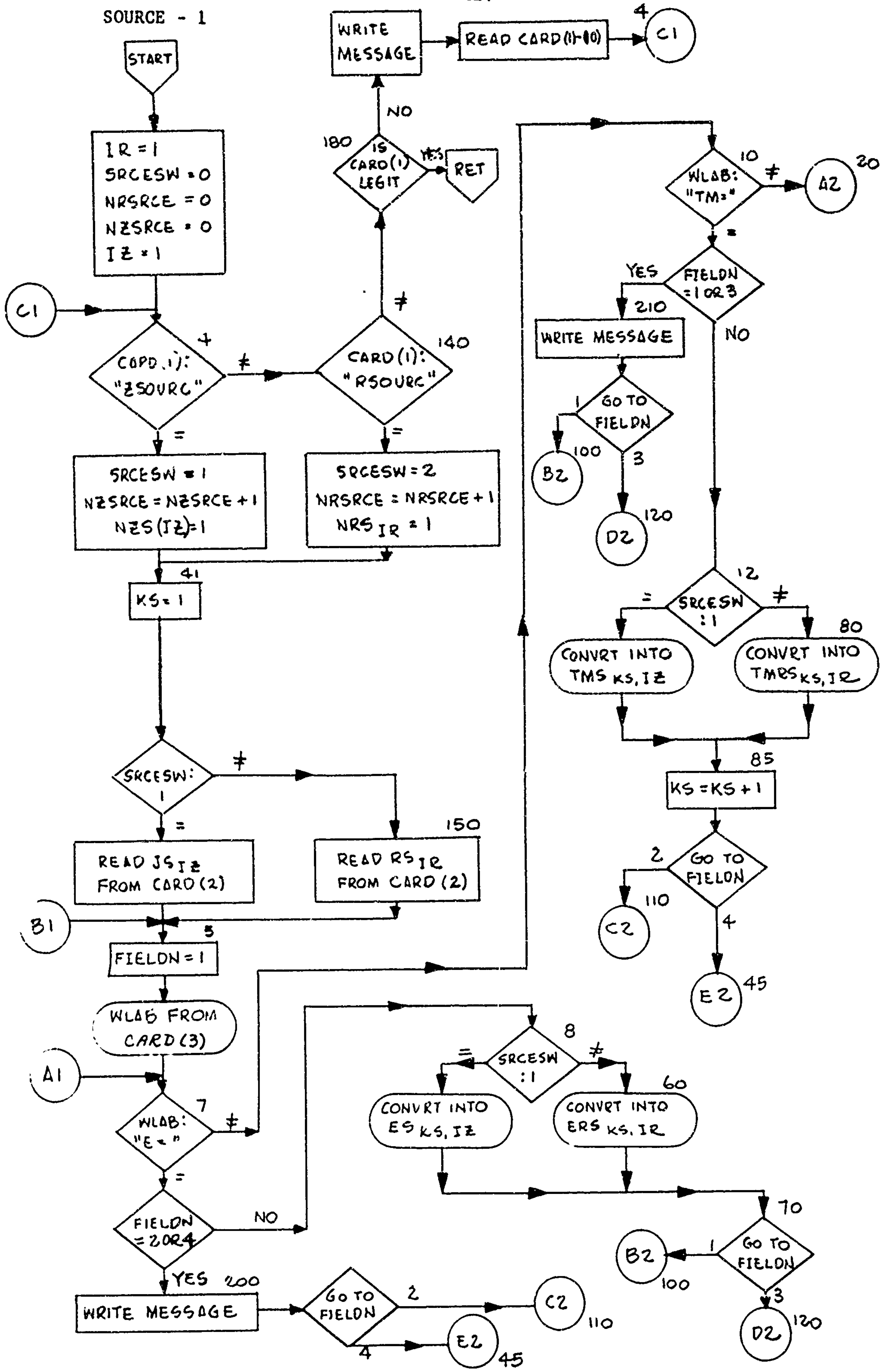
There are at most 6 steps in each source function: KS_{MAX} = 6.

```
$IBFTC SOURCE  REF
      SUBROUTINE SOURCE
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      INTEGER SRCESW,RS
      COMMON /ZURC/ZSOURC
      COMMON /RURC/RSOURC
      COMMON /BYBR/ BORYBR
      COMMON /CBIN/ COMBIN
      COMMON /ZMPE/ ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /FATA/ ENDATA
      COMMON /EQ/EEQ
      COMMON /TMQ/ TMEQ
      COMMON /BLNK/BLANK
      IR=1
      SRCESW=0
      NRSRCE=0
      NZSRCE=0
      IZ=1
```

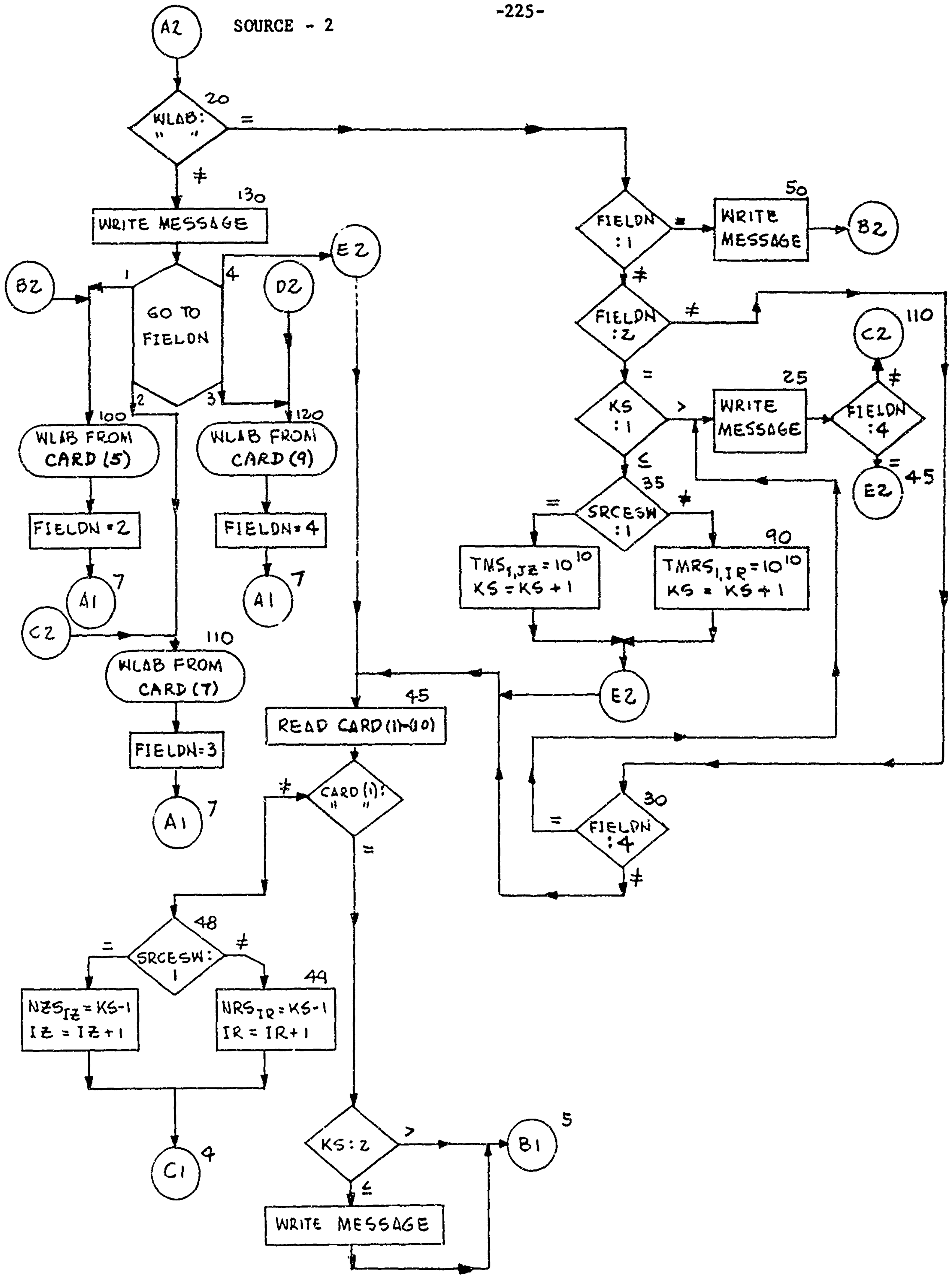
```
    4 IF (CARD(1).NE.ZSOURC) GO TO 140
      SRCESW=1
      NZSRCE=NZSRCE+1
      NZS(IZ)=1
41    KS=1
       IF (SRCESW.NE.1) GO TO 150
      JS(IZ)=CARD(2)
    5 FIELDN=1
      WLAB=CARD(3)
    7 IF (WLAB.NE.EEQ) GO TO 10
      IF (FIELDN.EQ.2.OR.FIELDN.EQ.4) GO TO 200
    8 IF (SRCESW.NE.1) GO TO 60
      IF (FIELDN.EQ.1)   ES(KS,IZ)=CARD( 4)
      IF (FIELDN.EQ.3)   ES(KS,IZ)=CARD( 8)
      GO TO 70
   10 IF (WLAB.NE.TMEQ) GO TO 20
      IF (FIELDN.EQ.1.OR.FIELDN.EQ.3) GO TO 210
   12 IF (SRCESW.NE.1) GO TO 80
      IF (FIELDN.EQ.2)  TMS(KS,IZ)=CARD( 6)
      IF (FIELDN.EQ.4)  TMS(KS,IZ)=CARD(10)
      GO TO 85
   20 IF (WLAB.NE.BLANK) GO TO 130
      IF (FIELDN.EQ.1) GO TO 50
      IF (FIELDN.NE.2) GO TO 30
      IF (KS.LE.1) GO TO 35
   25 ERFLAG=1
      WRITE (6,1005)
      WRITE (6,1) (CARD(I),I=1,10)
 1005 FORMAT (1H0,33H SOURCE FRMT1005  TM IS EXPECTED. /)
       IF(FIELDN.EQ.4) GO TO 45
      GO TO 110
   30 IF (FIELDN.EQ.4) GO TO 25
      GO TO 45
   35 IF (SRCESW.NE.1) GO TO 90
      TMS(1,IZ)=1.E+10
      KS=KS+1
      GO TO 45
   45 READ (5,1)    (CARD(I),I=1,10)
    1  FORMAT (A6,F6.0,4(A3,E12.6))
      IF (CARD(1).NE.BLANK) GO TO 48
      IF (KS.GT.2) GO TO 5
      ERFLAG=1
      WRITE (6,1040)
 1040 FORMAT (1H0,47H SOURCE FRMT1040  CARD PRECEDING IS INCOMPLETE.
      GO TO 5
48    IF (SRCESW.NE.1) GO TO 49
      NZS(IZ)=KS-1
      IZ=IZ+1
      GO TO 4
   49 NRS(IR)=KS-1
      IR=IR+1
      GO TO 4
   50 ERFLAG=1
      WRITE (6,1015)
      WRITE (6,1) (CARD(I),I=1,10)
 1015 FORMAT (1H0,39H SOURCE FRMT1015  FIRST FIELD IS BLANK. /)
      GO TO 100
```

```
   60 IF (FIELDN.EQ.1)  ERS(KS,IR)=CARD( 4)
      IF (FIELDN.EQ.3)  ERS(KS,IR)=CARD( 8)
   70 GO TO (100,200,120,200),    FIELDN
   80 IF (FIELDN.EQ.2) TMRS(KS,IR)=CARD( 6)
      IF (FIELDN.EQ.4) TMRS(KS,IR)=CARD(10)
   85 KS=KS+1
      GO TO (210,110,210,45),FIELDN
   90 TMRS(1,IR)=1.E+10
      KS=KS+1
      GO TO 45
  100 WLAB=CARD(5)
      FIELDN=2
      GO TO 7
  110 WLAB=CARD(7)
      FIELDN=3
      GO TO 7
  120 WLAB=CARD(9)
      FIELDN=4
      GO TO 7
  130 ERFLAG=1
      WRITE (6,1020)
      WRITE (6,1) (CARD(I),I=1,10)
 1020 FORMAT (1H0,41H SOURCE FRMT1020  CARD HAS ILLEGAL LABEL. /)
      GO TO (100,110,120,45),FIELDN
  140 IF (CARD(1).NE.RSOURC) GO TO 180
      SRCESW=2
      NRSRCE=NRSRCE+1
      NRS(IR)=1
      GO TO 41
  150 RS(IR)=CARD(2)
      GO TO 5
  180 IF (CARD(1).EQ.BDRYBB) RETURN
      IF (CARD(1).EQ.COMBIN) RETURN
      IF (CARD(1).EQ.ZTEMPE) RETURN
      IF (CARD(1).EQ.PERCEN) RETURN
      IF (CARD(1).EQ.ENDATA) RETURN
       ERFLAG=1
      WRITE (6,1050)
      WRITE (6,1) (CARD(I),I=1,10)
 1050 FORMAT (1H0,31H SOURCE FRMT1050  ILLEGAL CARD. /)
       GO TO 4
  200 ERFLAG=1
      WRITE (6,1030)
      WRITE (6,1) (CARD(I),I=1,10)
 1030 FORMAT (1H0,46H SOURCE FRMT1030  CAN'T HAVE E VALUE IN SECOND
     1,17H OR FOURTH FIELD. /)
      GO TO ( 8 ,110, 8 , 45),FIELDN
  210 ERFLAG=1
      WRITE (6,1035)
      WRITE (6,1) (CARD(I),I=1,10)
 1035 FORMAT (1H0,47H SOURCE FRMT1035  CAN'T HAVE TIME IN 1ST OR 3RD
     1, 7H FIELD. /)
      GO TO (100, 12,120, 12),FIELDN
      END
```

SOURCE - 1


START
IR = 1
SRCESW = 0
NRSRCE = 0
NZSRCE = 0
IZ = 1
C1
CARD(1): "ZSOURC"
CARD(1): "RSOURC"
140
SRCESW = 1
NZSRCE = NZSRCE + 1
NZS(IZ) = 1
SRCESW = 2
NRSRCE = NRSRCE + 1
NRS IR = 1
180
IS CARD(1) LEGIT
YES
RET
NO
WRITE MESSAGE
READ CARD(1-10)
4
C1
41
KS = 1
SRCESW: 1
READ JS IZ FROM CARD (2)
150
READ RS IR FROM CARD (2)
B1
5
FIELDN = 1
WLAB FROM CARD (3)
A1
7
WLAB: "E ="
FIELDN = 2 OR 4
NO
YES
200
WRITE MESSAGE
GO TO FIELDN
2
C2
110
4
E2
45
8
SRCESW : 1
60
CONVRT INTO ES KS, IZ
CONVRT INTO ERS KS, IR
70
GO TO FIELDN
1
B2
100
3
D2
120
10
WLAB: "TM="
A2
20
FIELDN = 1 OR 3
YES
210
WRITE MESSAGE
GO TO FIELDN
1
B2
100
3
D2
120
NO
12
SRCESW : 1
80
CONVRT INTO TMS KS, IZ
CONVRT INTO TMRS KS, IR
85
KS = KS + 1
GO TO FIELDN
2
C2
110
4
E2
45

SOURCE - 2



A2
20
WLAB: " "
=
≠
130
WRITE MESSAGE
GO TO FIELDN
1
2
3
4
E2
B2
D2
100
WLAB FROM CARD (5)
FIELDN = 2
A1
7
120
WLAB FROM CARD (9)
FIELDN = 4
A1
7
C2
110
WLAB FROM CARD (7)
FIELDN = 3
A1
7
FIELDN : 1
50
WRITE MESSAGE
B2
FIELDN : 2
KS : 1
>
25
WRITE MESSAGE
FIELDN : 4
C2
110
E2
45
≤
35
SRCESW : 1
90
$TMS_{1,JZ} = 10^{10}$
KS = KS + 1
$TMRS_{1,IR} = 10^{10}$
KS = KS + 1
E2
45
READ CARD (1)-(10)
CARD (1): " "
30
FIELDN : 4
48
SRCESW : 1
49
NZS_{IZ} = KS-1
IZ = IZ + 1
NRS_{IR} = KS-1
IR = IR + 1
C1
4
KS : 2
B1
5
WRITE MESSAGE

28. BOUND

BOUND is called by GENRAT. It reads and interprets the BOUNDARY cards.

```
$IBFTC BOUND   REF
      SUBROUTINE BOUND
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      COMMON /BYBB/BDRYBB
      COMMON /CBIN/ COMBIN
      COMMON /ZMPE/ ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /EATA/ ENDATA
      COMMON /MNMX/MINBB,MAXBB
      REAL MINBB,MAXBB,KEQ
      COMMON /UQ/UEQ
      COMMON /PQ/PEQ
      COMMON /EQ/EEQ
      COMMON /KQ/KEQ
      COMMON /TQ/TEQ
      COMMON /BLNK/BLANK
      COMMON /TMQ/TMEQ
    8 IF (CARD(1).NE.BDRYBB) GO TO 510
      MLAB=CARD(2)
      IF (MLAB.NE.0) GO TO 100
      BDRYSW=1
    9 KS=1
   10 WLAB=CARD(3)
      FIELDN=1
      IF (KS.GT.1) GO TO 20
      IF (WLAB.EQ.UEQ ) GO TO 120
      IF (WLAB.EQ.PEQ) GO TO 130
      IF (WLAB.EQ.EEQ) GO TO 140
      IF (WLAB.EQ.KEQ) GO TO 150
      IF (WLAB.EQ.TEQ) GO TO 160
       IF(WLAB.EQ.BLANK) GO TO 265
   15  ERFLAG=1
      WRITE (6,1000)
      WRITE (6,1) (CARD(I),I=1,10)
 1000 FORMAT (1H0,44H BOUND  FRMT1000  FOLLOWING CARD HAS ILLEGAL
     1, 7H LABEL. /)
      GO TO 90
   20 GO TO (420,440,470,490, 170),BTYPE
   40 IF (WLAB.EQ.TMEQ) GO TO 200
       GO TO 15
   45 GO TO ( 60, 70, 80, 90),FIELDN
   60 WLAB=CARD(5)
      FIELDN=2
       IF(WLAB.EQ.BLANK) GO TO 270
       GO TO 40
```

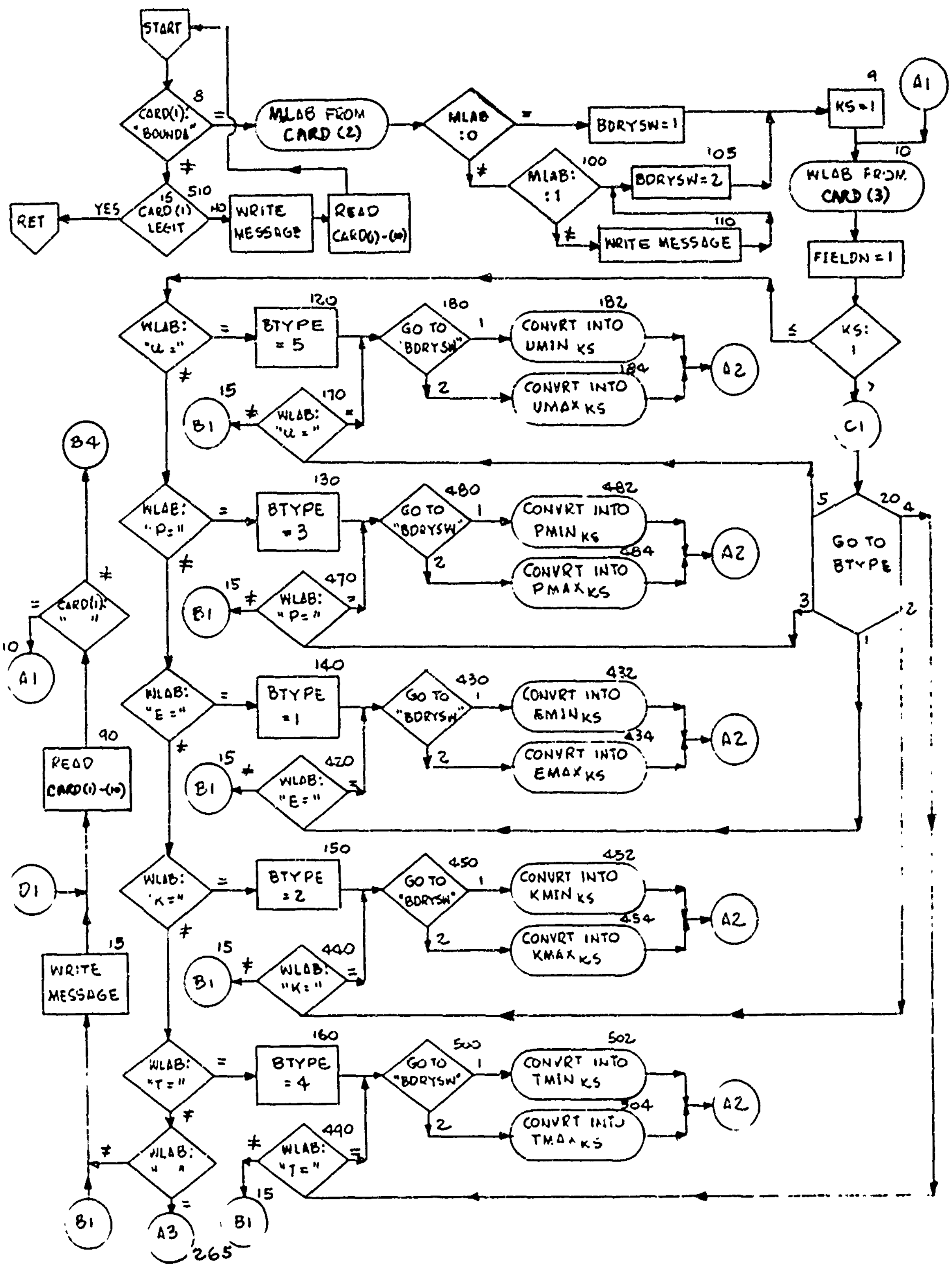
```
   70 WLAB=CARD(7)
      FIELDN=3
       IF(WLAB.EQ.BLANK) GO TO 350
      GO TO 20
   80 WLAB=CARD(9)
      FIELDN=4
       IF(WLAB.EQ.BLANK) GO TO 400
       GO TO 40
   90 READ (5,1) (CARD(I),I=1,10)
    1  FORMAT (A6,F6.0,4(A3,E12.6))
      IF (CARD(1).EQ.BLANK) GO TO 10
      GO TO 350
  100 IF (MLAB.NE.1) GO TO 110
  105 BDRYSW=2
      GO TO 9
  110 ERFLAG=1
      WRITE (6,1005)
      WRITE (6,1) (CARD(I),I=1,10)
 1005 FORMAT (1H0,48H BOUND FRMT1005   BOUNDARY CARD FOLLOWING HAS NO
     1,16H 'MAX' OR 'MIN'. /)
      GO TO 105
  120 BTYPE=5
       GO TO 180
  130 BTYPE=3
       GO TO 480
  140 BTYPE=1
       GO TO 430
  150 BTYPE=2
       GO TO 450
  160 BTYPE=4
       GO TO 500
  170  IF(WLAB.NE.UEQ) GO TO 15
  180 GO TO (182,184),BDRYSW
  182 IF (FIELDN.EQ.1)   UMIN(KS)=CARD( 4)
      IF (FIELDN.EQ.3)   UMIN(KS)=CARD( 8)
      GO TO 45
  184 IF (FIELDN.EQ.1)   UMAX(KS)=CARD( 4)
      IF (FIELDN.EQ.3)   UMAX(KS)=CARD( 8)
      GO TO 45
  200 GO TO (202,204),BDRYSW
  202 GO TO (240,230,220,210,206),BTYPE
  204 GO TO (245,235,225,215,208),BTYPE
  206 IF (FIELDN.EQ.2)  TUMIN(KS)=CARD( 6)
      IF (FIELDN.EQ.4)  TUMIN(KS)=CARD(10)
      GO TO 250
  208 IF (FIELDN.EQ.2)  TUMAX(KS)=CARD( 6)
      IF (FIELDN.EQ.4)  TUMAX(KS)=CARD(10)
      GO TO 250
  210 IF (FIELDN.EQ.2)  TTMIN(KS)=CARD( 6)
      IF (FIELDN.EQ.4)  TTMIN(KS)=CARD(10)
      GO TO 250
  215 IF (FIELDN.EQ.2)  TTMAX(KS)=CARD( 6)
      IF (FIELDN.EQ.4)  TTMAX(KS)=CARD(10)
      GO TO 250
```

```
220 IF (FIELDN.EQ.2)  TPMIN(KS)=CARD( 6)
    IF (FIELDN.EQ.4)  TPMIN(KS)=CARD(10)
    GO TO 250
225 IF (FIELDN.EQ.2)  TPMAX(KS)=CARD( 6)
    IF (FIELDN.EQ.4)  TPMAX(KS)=CARD(10)
    GO TO 250
230 IF (FIELDN.EQ.2)  TKMIN(KS)=CARD( 6)
    IF (FIELDN.EQ.4)  TKMIN(KS)=CARD(10)
    GO TO 250
235 IF (FIELDN.EQ.2)  TKMAX(KS)=CARD( 6)
    IF (FIELDN.EQ.4)  TKMAX(KS)=CARD(10)
    GO TO 250
240 IF (FIELDN.EQ.2)  TEMIN(KS)=CARD( 6)
    IF (FIELDN.EQ.4)  TEMIN(KS)=CARD(10)
    GO TO 250
245 IF (FIELDN.EQ.2)  TEMAX(KS)=CARD( 6)
    IF (FIELDN.EQ.4)  TEMAX(KS)=CARD(10)
250 KS=KS+1
    GO TO 45
265 ERFLAG=1
    WRITE (6,1020)
    WRITE (6,1) (CARD(I),I=1,10)
1020 FORMAT (1H0,45H BOUND FRMT1020   FIRST FIELD CAN'T BE BLANK. /)
     GO TO 90
270 IF (KS.LE.1) GO TO 280
    ERFLAG=1
    WRITE (6,1025)
    WRITE (6,1) (CARD(I),I=1,10)
1025 FORMAT (1H0,49H BOUND FRMT1025   CAN'T HAVE 2ND FIELD BLANK WITH
   1,21H MORE THAN ONE INPUT. /)
    GO TO 45
280 GO TO (290,295),BDRYSW
290 GO TO (330,324,316,308,300),BTYPE
295 GO TO (332,326,318,310,302),BTYPE
300 NUMIN=1
    TUMIN(1)=1.E+11
    GO TO 340
302 NUMAX=1
    TUMAX(1)=1.E+11
    GO TO 340
308 NTMIN=1
    TTMIN(1)=1.E+11
    GO TO 340
310 NTMAX=1
    TTMAX(1)=1.E+11
    GO TO 340
316 NPMIN=1
    TPMIN(1)=1.E+11
    GO TO 340
318 NPMAX=1
    TPMAX(1)=1.E+11
    GO TO 340
```

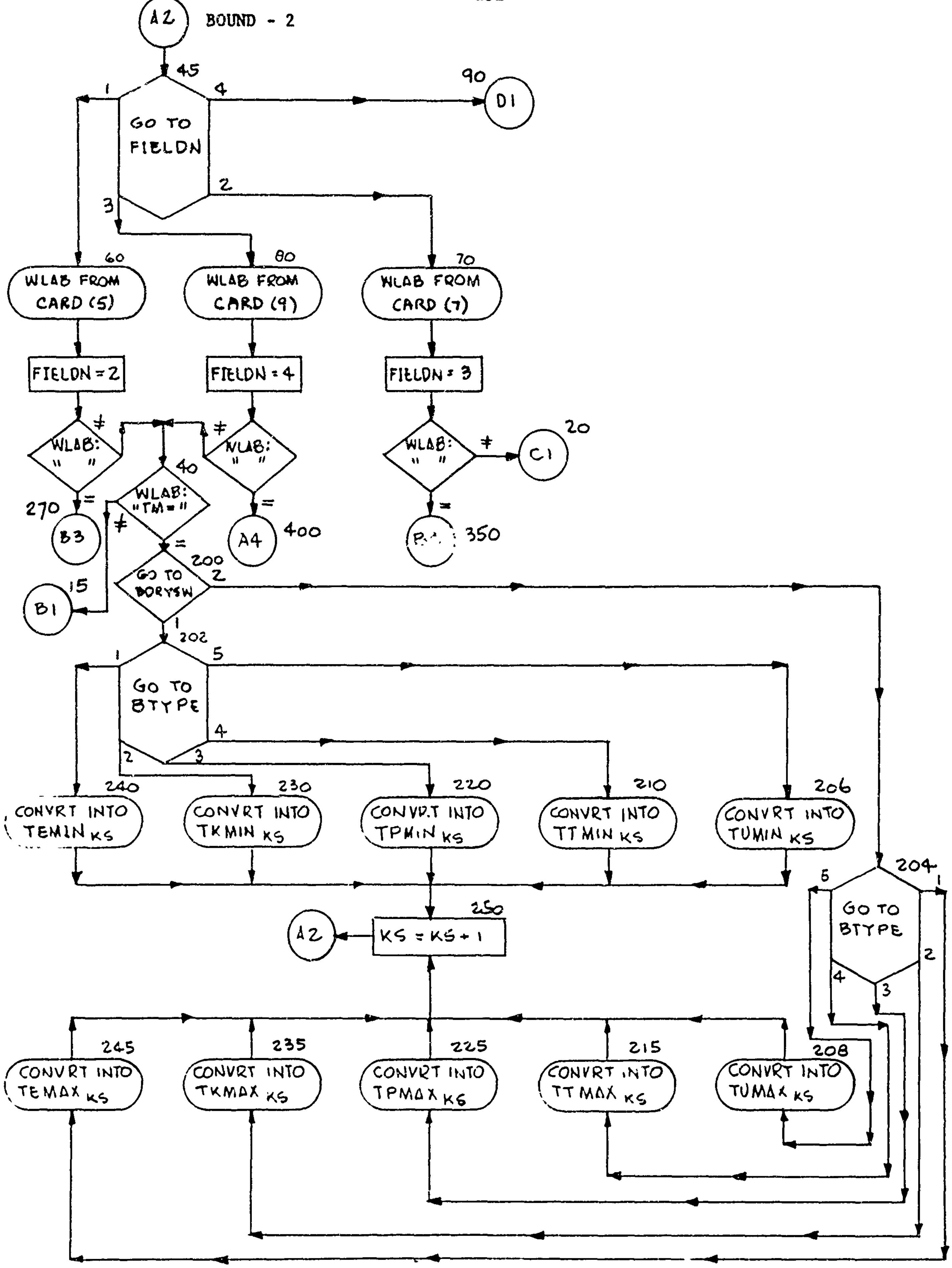
```
324 NKMIN=1
    TKMIN(1)=1.E+11
    GO TO 340
326 NKMAX=1
    TKMAX(1)=1.E+11
    GO TO 340
330 NEMIN=1
    TEMIN(1)=1.E+11
    GO TO 340
332 NEMAX=1
    TEMAX(1)=1.E+11
340 READ (5,1) (CARD(I),I=1,10)
    GO TO 8
350 KS=KS-1
    GO TO (355,360),BDRYSW
355 GO TO (364,370,376,384,390),BTYPE
360 GO TO (366,372,380,386,392),BTYPE
364 NEMIN=KS
    GO TO 340
366 NEMAX=KS
    GO TO 340
370 NKMIN=KS
    GO TO 340
372 NKMAX=KS
    GO TO 340
376 NPMIN=KS
    GO TO 340
380 NPMAX=KS
    GO TO 340
384 NTMIN=KS
    GO TO 340
386 NTMAX=KS
    GO TO 340
390 NUMIN=KS
    GO TO 340
392 NUMAX=KS
    GO TO 340
400 ERFLAG=1
    WRITE (6,1030)
    WRITE (6,1) (CARD(I),I=1,10)
1030 FORMAT (1H0,42H BOUND FRMT1030   'TM=' IS EXPECTED ON THE
    1,16H FOLLOWING CARD. /)
    GO TO 90
420 IF (WLAB.NE.EEQ) GO TO 15
430 GO TO (432,434),BDRYSW
432 IF (FIELDN.EQ.1)   EMIN(KS)=CARD( 4)
    IF (FIELDN.EQ.3)   EMIN(KS)=CARD( 8)
    GO TO 45
```

```
434 IF (FIELDN.EQ.1)   EMAX(KS)=CARD( 4)
    IF (FIELDN.EQ.3)   EMAX(KS)=CARD( 8)
    GO TO 45
440 IF (WLAB.NE.KEQ) GO TO 15
450 GO TO (452,454),BDRYSW
452 IF (FIELDN.EQ.1)   KMIN(KS)=CARD( 4)
    IF (FIELDN.EQ.3)   KMIN(KS)=CARD( 8)
    GO TO 45
454 IF (FIELDN.EQ.1)   KMAX(KS)=CARD( 4)
    IF (FIELDN.EQ.3)   KMAX(KS)=CARD( 8)
    GO TO 45
470 IF (WLAB.NE.PEQ) GO TO 15
480 GO TO (482,484),BDRYSW
482 IF (FIELDN.EQ.1)   PMIN(KS)=CARD( 4)
    IF (FIELDN.EQ.3)   PMIN(KS)=CARD( 8)
    GO TO 45
484 IF (FIELDN.EQ.1)   PMAX(KS)=CARD( 4)
    IF (FIELDN.EQ.3)   PMAX(KS)=CARD( 8)
    GO TO 45
490 IF (WLAB.NE.TEQ) GO TO 15
500 GO TO (502,504),BDRYSW
502 IF (FIELDN.EQ.1)   TMIN(KS)=CARD( 4)
    IF (FIELDN.EQ.3)   TMIN(KS)=CARD( 8)
    GO TO 45
504 IF (FIELDN.EQ.1)   TMAX(KS)=CARD( 4)
    IF (FIELDN.EQ.3)   TMAX(KS)=CARD( 8)
    GO TO 45
510 IF (CARD(1).EQ.COMBIN) RETURN
    IF (CARD(1).EQ.ZTEMPE) RETURN
    IF (CARD(1).EQ.PERCEN) RETURN
    IF (CARD(1).EQ.ENDATA) RETURN
     ERFLAG=1
    WRITE (6,7000)
    WRITE (6,1) (CARD(I),I=1,10)
7000 FORMAT (1H0,31H BOUND FRMT7000   ILLEGAL CARD. /)
     READ (5,1) CARD
     GO TO 8
    END
```

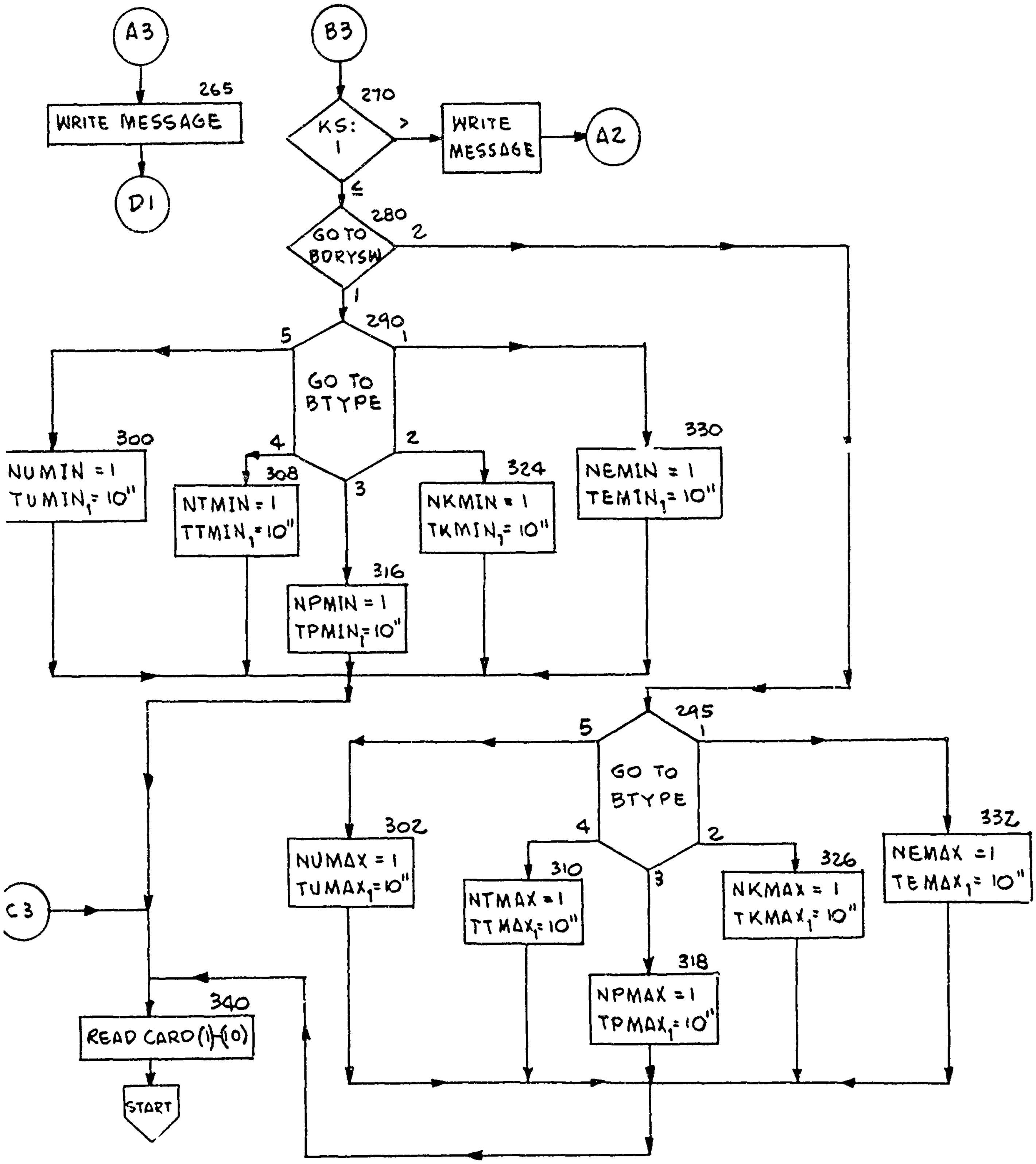
BOUND - 1



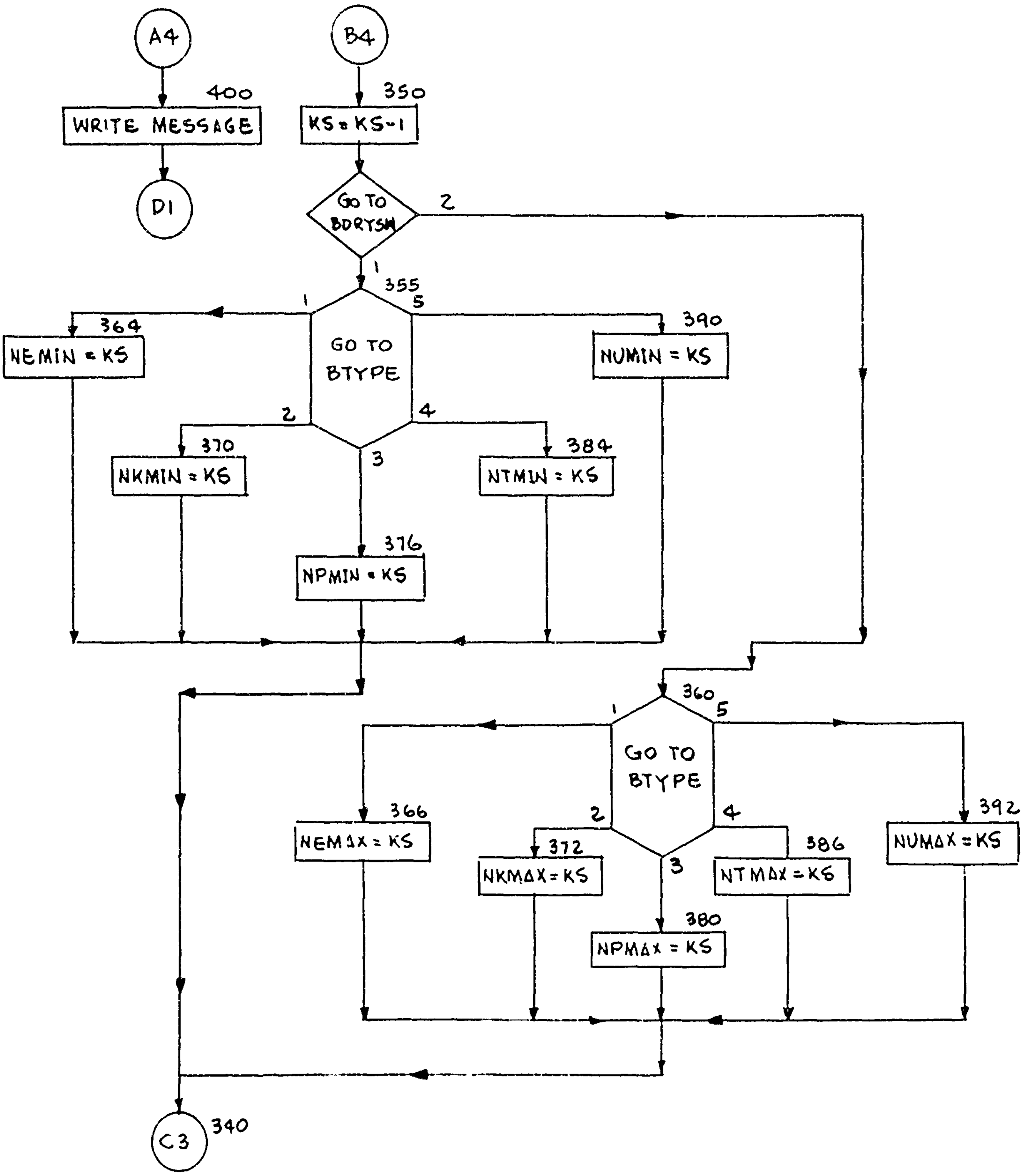
START
CARD(1): "BOUNDA"
MLAB FROM CARD (2)
MLAB :0
BDRYSW=1
KS=1
A1
MLAB: :1
BDRYSW=2
WLAB FROM CARD (3)
WRITE MESSAGE
FIELDN=1
RET
YES
CARD(1) LEGIT
NO
WRITE MESSAGE
READ CARD(1)-(10)
KS: 1
WLAB: "U="
BTYPE =5
GO TO "BDRYSW"
CONVRT INTO UMIN KS
CONVRT INTO UMAX KS
A2
B1
WLAB: "U="
C1
B4
WLAB: "P="
BTYPE =3
GO TO "BDRYSW"
CONVRT INTO PMIN KS
CONVRT INTO PMAX KS
GO TO BTYPE
CARD(1): " "
WLAB: "P="
A1
WLAB: "E="
BTYPE =1
GO TO "BDRYSW"
CONVRT INTO EMIN KS
CONVRT INTO EMAX KS
READ CARD(1)-(10)
WLAB: "E="
WLAB: "K="
BTYPE =2
GO TO "BDRYSW"
CONVRT INTO KMIN KS
CONVRT INTO KMAX KS
D1
WRITE MESSAGE
WLAB: "K="
WLAB: "T="
BTYPE =4
GO TO "BDRYSW"
CONVRT INTO TMIN KS
CONVRT INTO TMAX KS
WLAB: " "
WLAB: "T="
A3
265


A2
BOUND - 2
45
GO TO FIELDN
1
2
3
4
90
D1
60
WLAB FROM CARD (5)
80
WLAB FROM CARD (9)
70
WLAB FROM CARD (7)
FIELDN = 2
FIELDN = 4
FIELDN = 3
WLAB: " "
WLAB: " "
WLAB: " "
≠
=
270
B3
40
WLAB: "TM="
A4
400
20
C1
B4
350
200
GO TO BDRYSW
15
B1
202
GO TO BTYPE
5
240
CONVRT INTO TEMIN KS
230
CONVRT INTO TKMIN KS
220
CONVRT INTO TPMIN KS
210
CONVRT INTO TTMIN KS
206
CONVRT INTO TUMIN KS
204
GO TO BTYPE
250
A2
KS = KS + 1
245
CONVRT INTO TEMAX KS
235
CONVRT INTO TKMAX KS
225
CONVRT INTO TPMAX KS
215
CONVRT INTO TTMAX KS
208
CONVRT INTO TUMAX KS

BOUND - 3


A3
265
WRITE MESSAGE
D1
B3
270
KS: 1
>
≤
WRITE MESSAGE
A2
280
GO TO BDRYSW
2
1
290
GO TO BTYPE
5
1
4
2
3
300
NUMIN = 1
TUMIN1 = 10"
308
NTMIN = 1
TTMIN1 = 10"
316
NPMIN = 1
TPMIN1 = 10"
324
NKMIN = 1
TKMIN1 = 10"
330
NEMIN = 1
TEMIN1 = 10"
295
GO TO BTYPE
302
NUMAX = 1
TUMAX1 = 10"
310
NTMAX = 1
TTMAX1 = 10"
318
NPMAX = 1
TPMAX1 = 10"
326
NKMAX = 1
TKMAX1 = 10"
332
NEMAX = 1
TEMAX1 = 10"
C3
340
READ CARD(1)-(10)
START

BOUND - 4

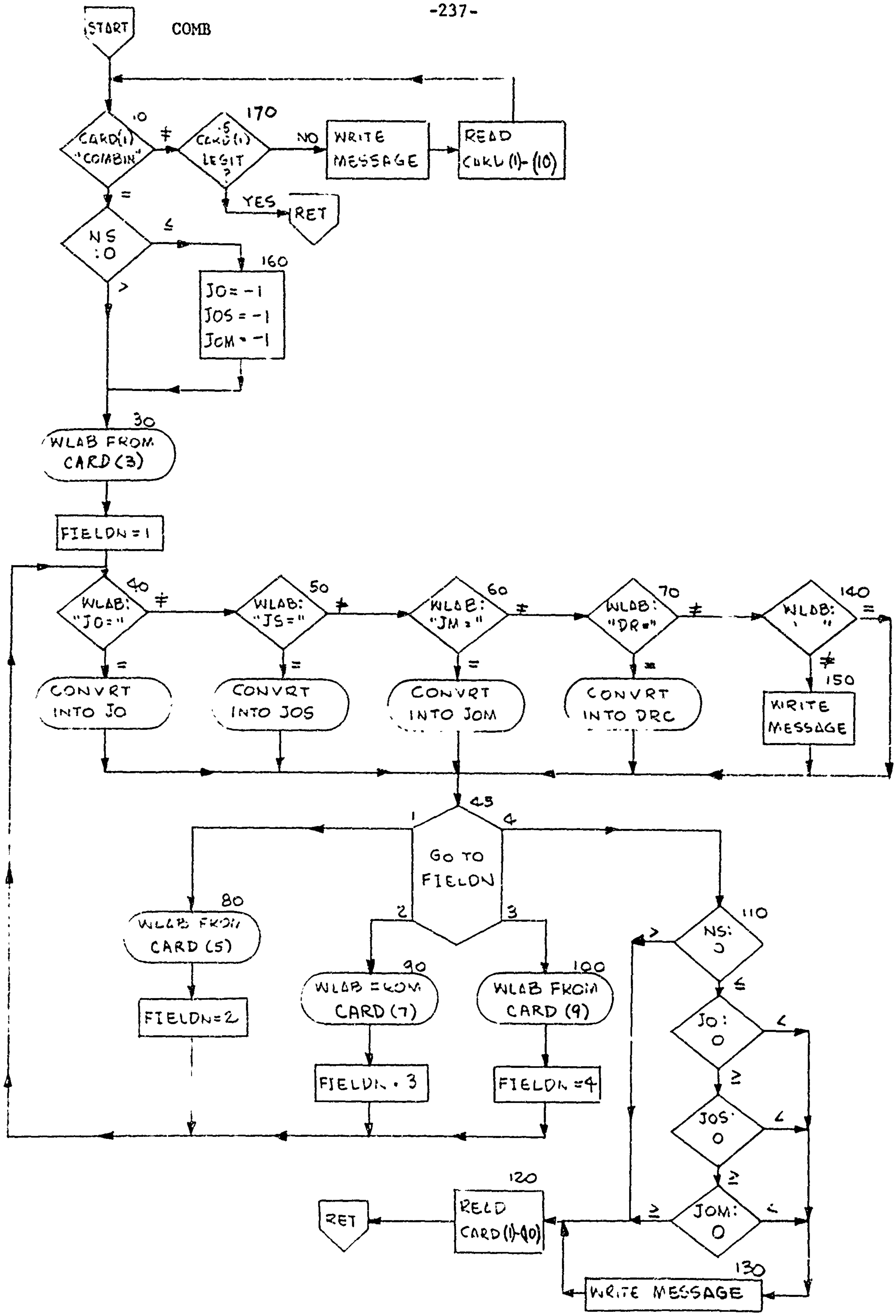

A4
400
WRITE MESSAGE
D1
B4
350
KS = KS-1
GO TO BDRYSW
2
1
355
1
5
GO TO BTYPE
364
NEMIN = KS
390
NUMIN = KS
2
4
3
370
NKMIN = KS
384
NTMIN = KS
376
NPMIN = KS
360
1
5
GO TO BTYPE
366
NEMAX = KS
2
4
3
372
NKMAX = KS
386
NTMAX = KS
392
NUMAX = KS
380
NPMAX = KS
C3
340

29. COMB

COMB reads and interprets the COMBINATION CARD.

```
$IBFTC COMB    REF
      SUBROUTINE COMB
C     COMMON CARDS LABELED /IKAI/ AND /IKAIA/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KEM, KP, KM
      COMMON /CBIN/COMBIN
      COMMON /ZMPE/ ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /EATA/ EDATA
      COMMON /JZEQ/ZJOEQ
      COMMON /JSEQ/ZJSEQ
      COMMON /JMEQ/ZJMEQ
      COMMON /DRQ/DREQ
      COMMON /BLNK/BLANK
   10 IF (CARD(1).NE.COMBIN ) GO TO 170
      IF (NS.LE.0) GO TO 160
   30 WLAB=CARD(3)
      FIELDN=1
   40 IF (WLAB.NE.ZJOEQ) GO TO 50
      IF (FIELDN.EQ.1)   JO=CARD( 4)
      IF (FIELDN.EQ.2)   JO=CARD( 6)
      IF (FIELDN.EQ.3)   JO=CARD( 8)
      IF (FIELDN.EQ.4)   JO=CARD(10)
   45 GO TO (80 , 90,100,110),FIELDN
   50 IF (WLAB.NE.ZJSEQ) GO TO 60
      IF (FIELDN.EQ.1)  JOS=CARD( 4)
      IF (FIELDN.EQ.2)  JOS=CARD( 6)
      IF (FIELDN.EQ.3)  JOS=CARD( 8)
      IF (FIELDN.EQ.4)  JOS=CARD(10)
      GO TO 45
   60 IF (WLAB.NE.ZJMEQ) GO TO 70
      IF (FIELDN.EQ.1)  JOM=CARD( 4)
      IF (FIELDN.EQ.2)  JOM=CARD( 6)
      IF (FIELDN.EQ.3)  JOM=CARD( 8)
      IF (FIELDN.EQ.4)  JOM=CARD(10)
      GO TO 45
   70 IF (WLAB.NE.DREQ) GO TO 140
      IF (FIELDN.EQ.1)  DRC=CARD( 4)
      IF (FIELDN.EQ.2)  DRC=CARD( 6)
      IF (FIELDN.EQ.3)  DRC=CARD( 8)
      IF (FIELDN.EQ.4)  DRC=CARD(10)
      GO TO 45
   80 WLAB=CARD(5)
      FIELDN=2
      GO TO 40
   90 WLAB=CARD(7)
      FIELDN=3
      GO TO 40
```

```
 100 WLAB=CARD(9)
     FIELDN=4
     GO TO 40
 110 IF (NS.GT.0) GO TO 120
     IF (JO.LT.0) GO TO 130
     IF (JOS.LT.0) GO TO 130
     IF (JOM.LT.0) GO TO 130
 120 READ (5,1) (CARD(I),I=1,10)
   1  FORMAT (A6,F6.0,4(A3,E12.6))
     RETURN
 130 ERFLAG=1
     WRITE (6,1000)
1000 FORMAT (1H0,49H COMB FRMT1000     INSUFFICIENT DATA FOR COMBIN
    1, 7H ZONES. /)
     GO TO 120
 140 IF (WLAB.NE.BLANK) GO TO 150
     GO TO 45
 150 ERFLAG=1
     WRITE (6,1005)
     WRITE (6,1) (CARD(I),I=1,10)
1005 FORMAT (1H0,32H COMB FRMT1005     ILLEGAL LABEL. /)
     GO TO 45
 160 JO=-1
     JOS=-1
     JOM=-1
     GO TO 30
 170 IF (CARD(1).EQ.ZTEMPE) RETURN
     IF (CARD(1).EQ.PERCEN) RETURN
     IF (CARD(1).EQ.ENDATA) RETURN
      ERFLAG=1
     WRITE (6,1010)
     WRITE (6,1) (CARD(I),I=1,10)
1010 FORMAT (1H0,31H COMB FRMT1010     ILLEGAL CARD. /)
      GO TO 10
     END
```


START
COMB
10
CARD(1) "COMBIN"
≠
=
170
LEGIT ?
NO
YES
WRITE MESSAGE
READ
RET
NS :0
≤
>
160
JO= -1
JOS = -1
JOM = -1
30
WLAB FROM CARD (3)
FIELDN=1
40
WLAB: "JO="
50
WLAB: "JS="
60
WLAB: "JM ="
70
WLAB: "DR="
140
WLAB: " "
CONVRT INTO JO
CONVRT INTO JOS
CONVRT INTO JOM
CONVRT INTO DRC
150
WRITE MESSAGE
45
GO TO FIELDN
1
2
3
4
80
CARD (5)
FIELDN=2
90
CARD (7)
FIELDN = 3
100
WLAB FROM CARD (9)
FIELDN =4
110
NS: 0
JO: 0
JOS: 0
JOM: 0
≥
<
120
CARD(1)-(10)
RET
130
WRITE MESSAGE

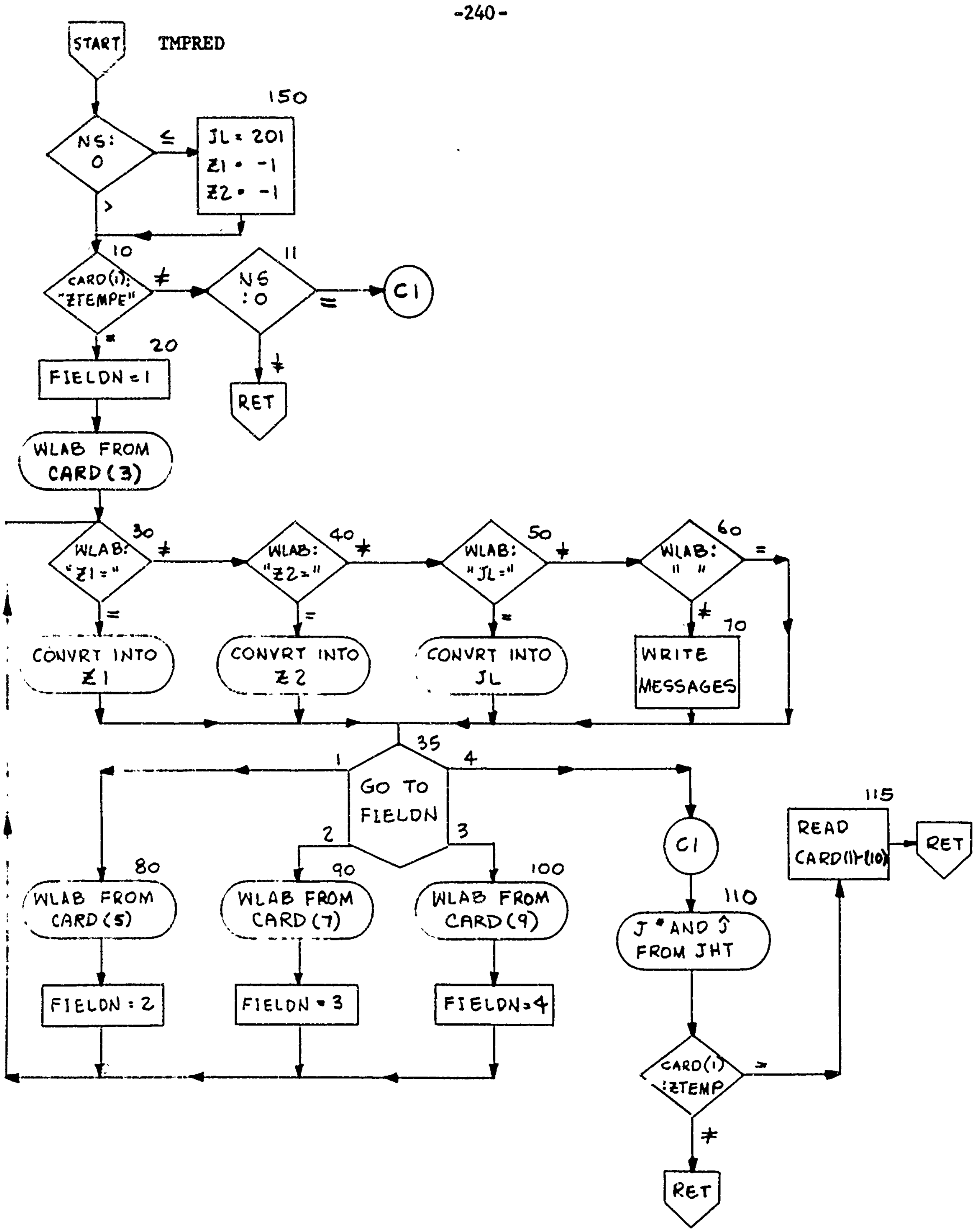
30. TMPRED

TMPRED reads and interprets the ZTEMPERATURE card. It is called by GENRAT.

```
$IBFTC TMPRD   REF
      SUBROUTINE TMPRD
C     COMMON CARDS LABELED /IKA1/ AND /IKA14/ GROUPS TO BE PLACED HER
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      COMMON /TEMC/ TEM(1)
       COMMON /UC/U(1)
      COMMON /ZMPE/ZTEMPE
      COMMON /PCEN/ PERCEN
      COMMON /EATA/ ENDATA
      COMMON /Z1Q/Z1EQ
      COMMON /Z2Q/Z2EQ
      COMMON /JLQ/ZJLEQ
      COMMON /BLNK/BLANK
      IF (NS.LE.0) GO TO 150
   10 IF (CARD(1).NE.ZTEMPE) GO TO 11
   20 FIELDN=1
      WLAB=CARD(3)
   30 IF (WLAB.NE.Z1EQ) GO TO 40
      IF (FIELDN.EQ.1)    Z1=CARD( 4)
      IF (FIELDN.EQ.2)    Z1=CARD( 6)
      IF (FIELDN.EQ.3)    Z1=CARD( 8)
      IF (FIELDN.EQ.4)    Z1=CARD(10)
   35 GO TO ( 80, 90,100,110),FIELDN
   40 IF (WLAB.NE.Z2EQ) GO TO 50
      IF (FIELDN.EQ.1)    Z2=CARD( 4)
      IF (FIELDN.EQ.2)    Z2=CARD( 6)
      IF (FIELDN.EQ.3)    Z2=CARD( 8)
      IF (FIELDN.EQ.4)    Z2=CARD(10)
      GO TO 35
   50 IF (WLAB.NE.ZJLEQ) GO TO 60
      IF (FIELDN.EQ.1)    JL=CARD( 4)
      IF (FIELDN.EQ.2)    JL=CARD( 6)
      IF (FIELDN.EQ.3)    JL=CARD( 8)
      IF (FIELDN.EQ.4)    JL=CARD(10)
      GO TO 35
   60 IF (WLAB.NE.BLANK) GO TO 70
      GO TO 35
   70 ERFLAG=1
      WRITE (6,1000)
      WRITE (6,1) (CARD(I),I=1,10)
 1000 FORMAT (1H0,32H TMPRD FRMT1000    ILLEGAL LABEL. /)
      GO TO 35
   80 WLAB=CARD(5)
      FIELDN=2
      GO TO 30
   90 WLAB=CARD(7)
      FIELDN=3
      GO TO 30
```

```
100 WLAB=CARD(9)
    FIELDN=4
    GO TO 30
110  CALL JHT(JHAT,JSTAR,JMAX,TEM(1),U(1),Z1,Z2)
    IF(CARD(1).NE.ZTEMPE)  RETURN
115 READ (5,1) (CARD(I),I=1,10)
  1  FORMAT (A6,F6.0,4(A3,E12.6))
    RETURN
150 Z1=-1.
    Z2=-1.
    JL = 201
    GO TO 10
 11 IF(NS.NE.0)  RETURN
     GO TO 110
    END
```

HER


START
TMPRED
150
NS:
0
JL = 201
Z1 = -1
Z2 = -1
10
CARD(1):
"ZTEMPE"
11
NS
:0
C1
20
FIELDN = 1
RET
WLAB FROM
CARD(3)
30
WLAB:
"Z1="
40
WLAB:
"Z2="
50
WLAB:
"JL="
60
WLAB:
" "
70
CONVRT INTO
Z1
CONVRT INTO
Z2
CONVRT INTO
JL
WRITE
MESSAGES
35
GO TO
FIELDN
115
READ
CARD(1)-(10)
RET
C1
80
WLAB FROM
CARD(5)
90
WLAB FROM
CARD(7)
100
WLAB FROM
CARD(9)
110
J* AND Ĵ
FROM JHT
FIELDN = 2
FIELDN = 3
FIELDN = 4
CARD(1)
:ZTEMP
RET

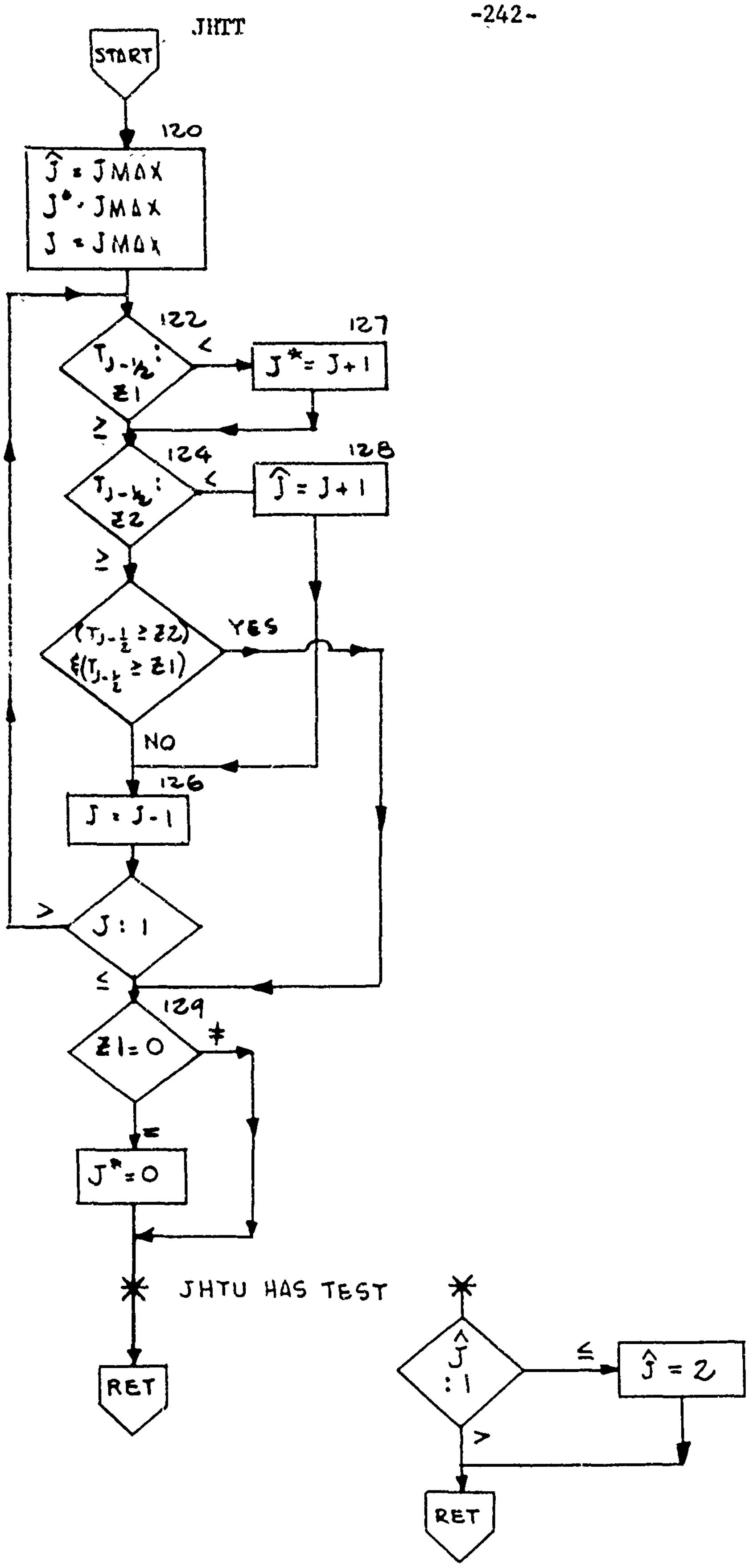
31. JHT($\hat{j}$,j^*,jmax,U,Z1,Z2)

JHT is called by TMPRED to determine j^* and $\hat{j}$. The deck named JHTT is used if Z2 is a temperature, and JHTU is used if Z2 is a velocity.

```
$IBFTC JHTT    REF
      SUBROUTINE JHT(JHAT,JSTAR,JMAX,TEM,U,Z1,Z2)
      DIMENSION TEM(1),U(1)
  120 JHAT=JMAX
      JSTAR=JMAX
      J=JMAX
  122 IF (TEM(J+1).LT.Z1) GO TO 127
  124 IF (TEM(J+1).LT.Z2) GO TO 128
      IF (TEM(J+1).GE.Z2.AND.TEM(J+1).GE.Z1) GO TO 129
  126 J=J-1
      IF (J.LE.1) GO TO 129
      GO TO 122
  127 JSTAR=J+1
      GO TO 124
  128 JHAT=J+1
      GO TO 126
  129 IF (Z1.EQ.0.) JSTAR=0
      RETURN
      END


$IBFTC JHTU    REF
       SUBROUTINE JHT(JHAT,JSTAR,JMAX,TEM,U,Z1,Z2)
       DIMENSION TEM(1),U(1)
 120  JHAT=JMAX
      JSTAR=JMAX
      J=JMAX
 122  IF (TEM(J+1).LT.Z1) GO TO 127
 124  IF (U(J).LT.Z2) GO TO 128
      IF(U(J).GE.Z2.AND.TEM(J+1).GE.Z1)  GO TO 129
 126  J=J-1
       IF(J.LE.1) GO TO 129
      GO TO 122
 127  JSTAR=J+1
      GO TO 124
 128  JHAT=J+1
      GO TO 126
  129  IF(Z1.EQ.0.) JSTAR =0
       IF(JHAT.LE.1) JHAT=2
       RETURN
       END
```

JHTT



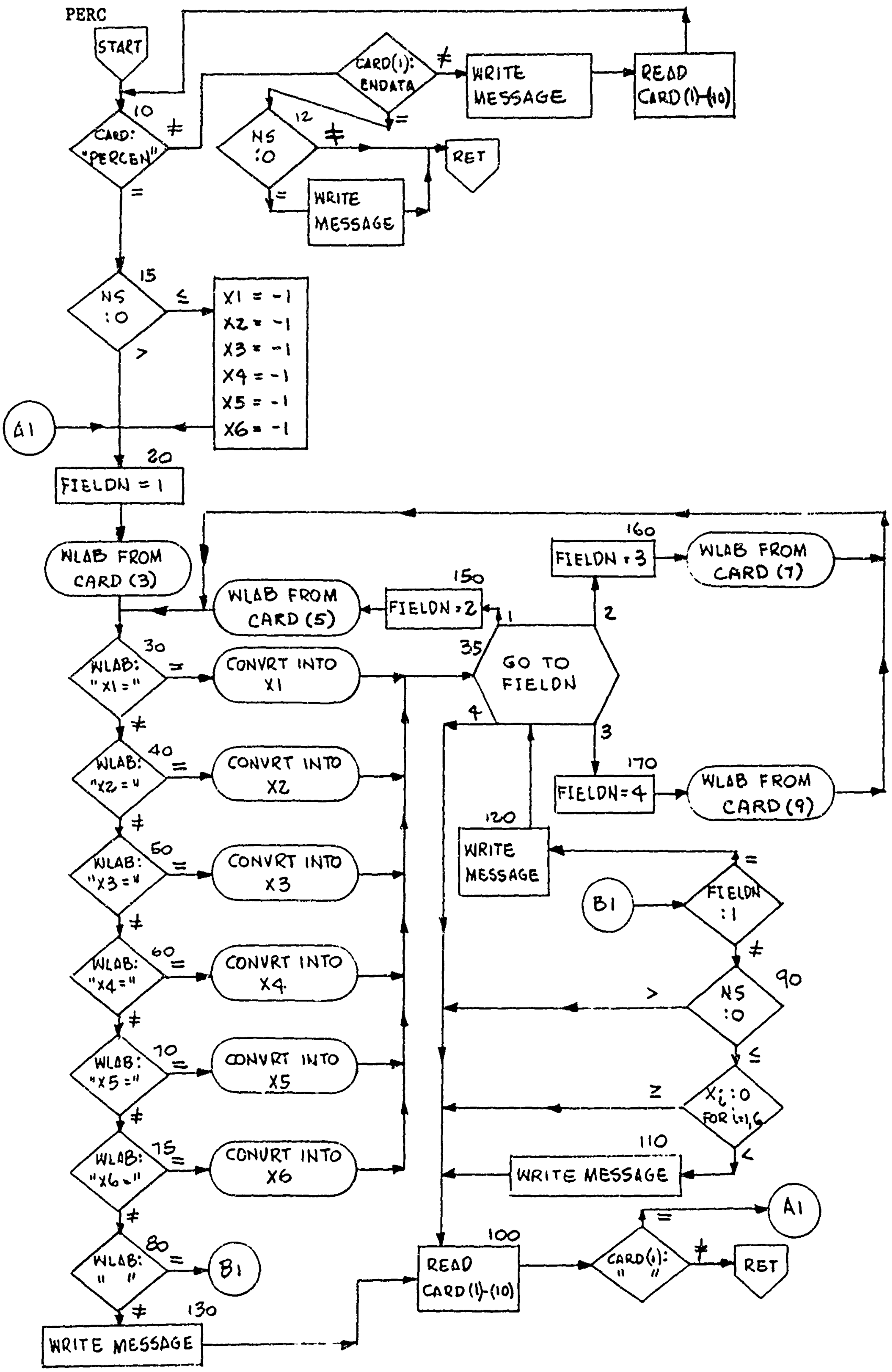
JHTU IS IDENTICAL WITH THE EXCEPTION THAT U_{J-1} IS TESTED AGAINST Z2, NOT $T_{J-1/2}$

32. PERC

PERC reads and interprets the PERCENTS cards. It is called by GENRAT.

```
$IBFTC PERC    REF
      SUBROUTINE PERC
C     COMMON CARDS LABELED /IKA1/ AND /IKA1A/ GROUPS TO BE PLACED HERE
C     INTEGER CARD GROUP TO BE PLACED HERE
      REAL KVAL, KZAL, KMIN, KMAX, KDM, KP, KM
      COMMON /PCEN/PERCEN
      COMMON /EATA/ ENDATA
      COMMON /X1Q/X1EQ
      COMMON /X2Q/X2EQ
      COMMON /X3Q/X3EQ
      COMMON /X4Q/X4EQ
      COMMON /X5Q/X5EQ
      COMMON /X6Q/X6EQ
      COMMON /BLNK/BLANK
   10 IF (CARD(1).EQ.PERCEN)  GO TO 15
      IF (CARD(1).EQ.ENDATA) GO TO 12
      WRITE (6,1020)
      WRITE (6,1) (CARD(I),I=1,10)
 1020 FORMAT (1H0,32H PERC FRMT1020    ILLEGAL LABEL. /)
      READ (5,1) (CARD(I),I=1,10)
    1  FORMAT (A6,F6.0,4(A3,E12.6))
       GO TO 10
   12  IF (NS.EQ.0) WRITE (6,1000)
      RETURN
   15 IF (NS.GT.0) GO TO 20
      X1=-1.
      X2=-1.
      X3=-1.
      X4=-1.
      X5=-1.
      X6=-1.
   20 FIELDN=1
      WLAB=CARD(3)
   30 IF (WLAB.NE.X1EQ) GO TO 40
      IF (FIELDN.EQ.1)   X1=CARD( 4)
      IF (FIELDN.EQ.2)   X1=CARD( 6)
      IF (FIELDN.EQ.3)   X1=CARD( 8)
      IF (FIELDN.EQ.4)   X1=CARD(10)
   35 GO TO (150,160,170,100),FIELDN
   40 IF (WLAB.NE.X2EQ) GO TO 50
      IF (FIELDN.EQ.1)   X2=CARD( 4)
      IF (FIELDN.EQ.2)   X2=CARD( 6)
      IF (FIELDN.EQ.3)   X2=CARD( 8)
      IF (FIELDN.EQ.4)   X2=CARD(10)
      GO TO 35
   50 IF (WLAB.NE.X3EQ) GO TO 60
      IF (FIELDN.EQ.1)   X3=CARD( 4)
```

```
      IF (FIELDN.EQ.2)   X3=CARD( 6)
      IF (FIELDN.EQ.3)   X3=CARD( 8)
      IF (FIELDN.EQ.4)   X3=CARD(10)
      GO TO 35
   60 IF (WLAB.NE.X4EQ) GO TO 70
      IF (FIELDN.EQ.1)   X4=CARD( 4)
      IF (FIELDN.EQ.2)   X4=CARD( 6)
      IF (FIELDN.EQ.3)   X4=CARD( 8)
      IF (FIELDN.EQ.4)   X4=CARD(10)
      GO TO 35
   70 IF (WLAB.NE.X5EQ) GO TO 75
      IF (FIELDN.EQ.1)   X5=CARD( 4)
      IF (FIELDN.EQ.2)   X5=CARD( 6)
      IF (FIELDN.EQ.3)   X5=CARD( 8)
      IF (FIELDN.EQ.4)   X5=CARD(10)
      GO TO 35
   75 IF (WLAB.NE.X6EQ) GO TO 80
      IF (FIELDN.EQ.1)   X6=CARD( 4)
      IF (FIELDN.EQ.2)   X6=CARD( 6)
      IF (FIELDN.EQ.3)   X6=CARD( 8)
      IF (FIELDN.EQ.4)   X6=CARD(10)
      GO TO 35
   80 IF (WLAB.NE.BLANK) GO TO 130
      GO TO (120,90,90,90),FIELDN
   90 IF (NS.GT.0) GO TO 100
      IF (X1.LT.0.)GO TO 110
      IF (X2.LT.0.)GO TO 110
      IF (X3.LT.0.)GO TO 110
      IF (X4.LT.0.)GO TO 110
      IF (X5.LT.0.)GO TO 110
      IF (X6.LT.0.)GO TO 110
  100 READ (5,1) (CARD(I),I=1,10)
      IF (CARD(1).EQ.BLANK) GO TO 20
      RETURN
  110 ERFLAG=1
      WRITE (6,1000)
 1000 FORMAT (1H0,48H PERC FRMT1000    INCOMPLETE PERCENT DATA GIVEN. /)
      GO TO 100
  120 ERFLAG=1
      WRITE (6,1010)
      WRITE (6,1) (CARD(I),I=1,10)
 1010 FORMAT (1H0,43H PERC FRMT1010    FIRST FIELD IS BLANK ON--   /)
      GO TO 35
  130 ERFLAG=1
      GO TO 100
  150 FIELDN=2
      WLAB=CARD(5)
      GO TO 30
  160 FIELDN=3
      WLAB=CARD(7)
      GO TO 30
  170 FIELDN=4
      WLAB=CARD(9)
      GO TO 30
      END
```


PERC
START
10
CARD: "PERCEN"
CARD(1): ENDATA
WRITE MESSAGE
READ CARD(1)-(10)
12
NS :0
RET
WRITE MESSAGE
15
NS :0
X1 = -1
X2 = -1
X3 = -1
X4 = -1
X5 = -1
X6 = -1
A1
20
FIELDN = 1
WLAB FROM CARD (3)
150
FIELDN = 2
WLAB FROM CARD (5)
160
FIELDN = 3
WLAB FROM CARD (7)
170
FIELDN = 4
WLAB FROM CARD (9)
35
GO TO FIELDN
30
WLAB: "X1="
CONVRT INTO X1
40
WLAB: "X2="
CONVRT INTO X2
50
WLAB: "X3="
CONVRT INTO X3
60
WLAB: "X4="
CONVRT INTO X4
70
WLAB: "X5="
CONVRT INTO X5
75
WLAB: "X6="
CONVRT INTO X6
80
WLAB: " "
B1
130
WRITE MESSAGE
120
WRITE MESSAGE
B1
FIELDN :1
90
NS :0
Xi :0 FOR i=1,6
110
WRITE MESSAGE
100
READ CARD(1)-(10)
CARD(1): " "
A1
RET

33. GETLAB(N1,N2,WLAB) (RAND version only)

GETLAB gets the BCD from columns N1 to N2 of the twelve BCD words, CARD(I), I=1,12, (a single card image) and returns them in WLAB, left adjusted and filled in at the right with BCD blanks.

34. CONVRT(FIELDN,N,ANS) (RAND version only)

CONVRT converts the information found in columns 16-27, 31-42, 46-57 or 61-72 of the BCD card image CARD(I), I=1,12 as FIELDN is 1, 2, 3 or 4 respectively. The columns are converted to an integer or floating point number as N is 1 or 2 respectively and the results are stored at ANS.

35. CHGWD(X,JF) (RAND version only)

CHGWD rereads a variable as an integer or floating point number.

36. IKAERR

IKAERR prints a message and calls exit when ALIBI is reached illegally.

```
$IBFTC IKAERR  REF
       SUBROUTINE IKAERR
      PRINT 7000
 7000 FORMAT (24H0ALIBI HAS BEEN REACHED. )
      CALL EXIT
      END
```

37A. ALIBI (RAND version)

ALIBI is a collection of dummy entry points to all the possible analytic equation of state routines so only those being used need actually be included in the deck. The entry points contained are:

FP1000	FE1000	FK1000
FP1001	FE1001	FK1001
FP1002	FE1002	FK1002
FP1003	FE1003	FK1003
FP1004	FE1004	FK1004
FP1005	FE1005	FK1005

37B. ALIBI (All-FORTRAN version)

Prints out a message that "ALIBI HAS BEEN REACHED."

```
$IBFTC ALIBI   REF
      SUBROUTINE ALIBI
      CALL IKAERR
      RETURN
      END
```

```
$IBFTC FP1000
      FUNCTION FP1000(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1001
      FUNCTION FP1001(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1002
      FUNCTION FP1002(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1003
      FUNCTION FP1003(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1004
      FUNCTION FP1004(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1005
      FUNCTION FP1005(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FE1000
      FUNCTION FE1000(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FE1001
      FUNCTION FE1001(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FE1002
      FUNCTION FE1002(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FE1003
      FUNCTION FE1003(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FE1004
      FUNCTION FE1004(T,V)
```

```
      CALL IKAERR
      RETURN
      END
$IBFTC FE1005
      FUNCTION FE1005(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FK1000
      FUNCTION FK1000(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FK1001
      FUNCTION FK1001(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FK1002
      FUNCTION FK1002(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FK1003
      FUNCTION FK1003(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FK1004
      FUNCTION FK1004(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FK1005
      FUNCTION FK1005(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC DROA
      SUBROUTINE ROA(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DPET
      SUBROUTINE PET
      CALL IKAERR
      RETURN
      END
$IBFTC DTSR
      SUBROUTINE TSR(C)
      CALL IKAERR
      RETURN
      END
```

```
$IBFTC DROAXP
       SUBROUTINE ROAEXP(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DTSRXP
       SUBROUTINE TSREXP(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DCDR
       SUBROUTINE CDR(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DROAMP
       SUBROUTINE ROAIMP(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DROB
       SUBROUTINE ROB(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DROC
       SUBROUTINE ROC(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DRDI
       SUBROUTINE RDI(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DROD
       SUBROUTINE ROD(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DROE
       SUBROUTINE ROE(C)
       CALL IKAERR
       RETURN
       END
$IBFTC DTSRMP
       SUBROUTINE TSRIMP(C)
       CALL IKAERR
       RETURN
       END
```

```
$IBFTC DRBND
      SUBROUTINE RBOUND(TM,RHO)
      CALL IKAERR
      RETURN
      END
$IBFTC DPBND
       SUBROUTINE PBOUND (TM,PRJMP2)
      PRJMP2 = 0.
      RETURN
      END
$IBFTC DZNSRF
      FUNCTION ZNSRFN(J,SFN)
      ZNSRFN=0.
      RETURN
      END
$IBFTC DRGSRF
      FUNCTION RGSRFN(NR,SFN)
      RGSRFN=0.
      RETURN
      END
```

VI. DESCRIPTION OF "EXECUTE" PROGRAM

INTRODUCTION

The Executor portion of HAROLD requires a previously generated problem to be written on the history tape as cycle 0. The history tape must be on FORTRAN logical 12. The Executor reads cycle 0 from the history tape, calculates the problem, cycle by cycle, and prints and writes history cycles at previously specified times or cycles. It terminates calculating when the cycle number reaches NF or when an interval timer overflow occurs.

This portion of HAROLD requires a restart card (and for the RAND version, an output description deck; the form of these cards is discussed on the following page).

A problem may also be restarted with this section of HAROLD if no changes are to be made to the data. If any changes are to be made, the restart option of the Generator must be used before the Executor is used.

If tabular equations of state are required, they should be in the form produced by TABCOE (see Section VII) and mounted on FORTRAN logical 8.

DATA DESCRIPTION

The Executor section of HAROLD requires a restart card (and, for the RAND version, an output description deck). The restart card is of the form NS,IRAD,$IDENT_{1-6}$ with format (2I6,10A6). The parameters are:

NS: This is the cycle number from which to restart. It is 0 for a problem which has just been generated. The problem is restarted from the first cycle on the history tape with a cycle number greater than or equal to NS, but any very large number will result in restarting from the last cycle on the history tape.

IRAD: This is 1 for hydrodynamics only, 2, 3 or 4 for explicit radiation and 5, 6 or 7 for implicit radiation.

IDENT: This is 60 characters of BCD information to be printed at the start of the output.

The output description deck consists of 25 cards. Each card corresponds to a possible output variable. In columns 61-66 of those cards corresponding to output variables desired, the user specifies the order in which he wishes them to occur on the line. In columns 67-72 he specifies the number of significant figures desired. He then circles the units in which he would like the variable to be output. All numbers should be right-adjusted. The total number of significant figures desired (the sum of the numbers in columns 67-72) plus 7 times the number of output variables requested must not exceed 128. The keypuncher punches columns 1-6 and 61-80 of all 25 cards as well as those groups of six columns specifying units which have been circled. A sample output description sheet follows and an example of its use is included in the test case data descriptions in Section IX.

Keypuncher: Punch cols. 1-6 and 61-80 on all 25 cards. Also punch any blocks of six cols. which are circled

OUTPUT DESCRIPTION DECK (RAND VERSION ONLY) EXAMPLE OF TEST CASE 1 OUTPUT

000000 123456	000111 789012	111111 345678	122222 901234	222223 567890	333333 123456	333444 789012	444444 345678	455555 901234	55555c 567890	Position Line 666666 123456	No. of Sig. Figures 666777 789012	Item No. 777777 345678	78 90
RADIUS	CM	METERS	KM	INCHES	FEET	MILES	NAUTMI	KFT		1	6	1	
RADAVG	CM	METERS	KM	INCHES	FEET	MILES	NAUTMI	KFT				2	
PVELOC	CM/SEC	M/MS	CM/SH	M/SEC	IN/SEC	FT/SEC	MI/HR			2	4	3	
PRESUR	DY/CM2	JK/M3	BAR	KBAR	MEGBAR	JK/CM3	MILLIB	PSI		6	4	4	
DENSTY	GM/CM3	MEG/M3	KG/M3	LB/FT3	GM/M3	MIG/M3				3	4	5	
INTENG	ERG/GM	JK/MEG	CAL/GM	JK/GM	KT/LB					5	4	6	
TEMP	KELVIN	10**4K	EV	KEV	FARANH	RANKIN				4	4	7	
TEMAVG	KELVIN	10**4K	EV	KEV	FARANH	RANKIN						8	
MASS	GM/STR	MEG/ST	GRAMS	KGM	MEGRM	LB/STR	LBS	TONS		8	4	9	
DYNPRS	DY/CM2	JK/M3	BAR	KBAR	MEGBAR	JK/CM3	MILLIB	PSI				10	
ARTVIS	DY/CM2	JK/M3	BAR	KBAR	MEGBAR	JK/CM3	MILLIB	PSI		7	4	11	
DELRAD	CM	METERS	KM	INCHES	FEET	MILES	NAUTMI	KFT				12	
DEPLET	EG/G/S	J/M/MS	C/G/SC	JK/G/S	K/L/MS	KT/L/S	KT/T/S					13	
LMNSTY	ERG/SC	J/A/MS	E/ST/S	KT/SEC	CAL/SC	TN/SEC	MT/SEC					14	
ROSMFP	CM	METERS	KM	INCHES	FEET	MILES	NAUTMI	KFT				15	
ROPCTY	CM2/GM	M2/MEG										16	
EMSMFP	CM	METERS	KM	INCHES	FEET	MILES	NAUTMI	KFT				17	
NETPWR	ERG/SC	J/A/MS	E/ST/S	KT/SEC	CAL/SC	TN/SEC	MT/SEC					18	
BBPOWR	ERG/SC	J/A/MS	E/ST/S	KT/SEC	CAL/SC	TN/SEC	MT/SEC					19	
RALORT	ERG/SC	J/A/MS	E/ST/S	KT/SEC	CAL/SC	TN/SEC	MT/SEC					20	
RADLOS	ERG/DT	J/A/DT	E/A/DT	KT/DT	C/DELT	T/DELT	MT/DT					21	
MOPCTY	CMSK/E	HAR-U*	CGS.ST									22	
												23	
		*HAR-U =	$\frac{M^4(10^4\ ^\circ K)^4\ MS \cdot sterad}{jerk}$									24	
												25	

1234567890123456789012345678901234567890123456789012345678901234567890123456789 0

EQUATION OF STATE HANDLING

Equations of state may be either analytic or tabular or both. There may be a maximum of six of either type. Tabular equations of state should be on a binary tape in the form prepared by TABCOE and mounted on FORTRAN logical tape 8.

For problems using explicit or implicit radiation,analytic equations of state are introduced through function type subroutines calculating P(T,V), E(T,V) and K(T,V). For a region having the material number 100x, these function type subroutines have the names FP100x, FE100x and FK100x respectively. The form of the subroutine calculating P(T,V) for material 1003 would be:

```
$IBFTC FP1003
       FUNCTION  FP1003(T,V)
       FP1003 = some expression using T and V
       RETURN
       END
```

and the form of the subroutines calculating E(T,V) and K(T,V) would be similar.

Additional flexibility in the form of analytic equations of state is permitted for problems using hydrodynamics only. This additional flexibility is introduced through the use of a subroutine called PET. For equations of state of the form P(T,V) and E(T,V) the standard form of PET (see p. 330) is used and these equations of state are included as function subroutines of the form described above. If the equations of state are of the form P(E,V) and T(E,V) the equations of state are calculated by the subroutine PET and no function type subroutines are included. Using equations of state of this form saves computing time.

In this case $\hat{j}$ must, of course, be determined from a velocity condition, not a temperature condition. See page 285.

The form of the PET subroutine is in this case:

```
$IBFTC PET
       SUBROUTINE  PET(MAT,T,V,P,E,J,C)
       P = some expression using E and V
       T = some expression using E and V, if T is desired
       RETURN
       END
```

```
      EXECUTE SECTION  COMMONS NOTE

C       THE CONTINUATION CARD 4 OF COMMON /IKA2B/ HAS THE FOLLOWING DIF-
C     1  FERENCE IN TWO SUBROUTINES.    THIS CARD IS NOT IN SUBROUTINES
C     2  ECHECK OR GETVAR.



      THE FOLLOWING GROUPS OF CARDS SHOULD REPLACE THE COMMENTS CARDS
      WHICH ARE USED IN THE LISTINGS FOR THE SUBROUTINES.


C       THE COMMON /IKA2/  GROUP IS AS FOLLOWS

        COMMON /IKA2/ ERS(6,10), ES(6,10), TMRS(6,10), TMS(6,10), RS(10),
      1 JS(10), NRS(10), NZS(10), RRG(15), JREG(15), C1(15), C2(15),
      2 C3(15), C4(15), C5(15), E0(15), EMIN(6), EMAX(6), KMIN(6),
      3 KMAX(6), PMIN(6), PMAX(6), TMIN(6), TMAX(6), UMIN(6), UMAX(6),
      4TEMIN(6), TEMAX(6), TKMIN(6), TKMAX(6), TPMIN(6), TPMAX(6), NKMAX,
      5 TTMIN(6), TTMAX(6), TUMIN(6), TUMAX(6), NEMIN, NEMAX, NKMIN,
      6 NPMIN, NPMAX, NTMIN, NTMAX, NUMIN, NUMAX, NRSRCE, NZSRCE,
      7 J0, JOS, JCM, DRC, Z1, Z2, JL, X1, X2, X3, X4, X5, X6, NS,NF,
      8 UNCGS, UNMKS, TM, DT, DTP, JSTAR, JHAT, JMAX, DELTA, REGNC, JZ,
      9 NREG, NEOS, RMIN, RMAX, IRAD

C       THE COMMON /IKA2B/ GROUP IS AS FOLLOWS

        COMMON /IKA2B/ NDH(6), NHC(6), DTH(6), CTH(6), NDP(6), NPC(6),
      1  DTPR(6), CTP(6), NDCK(6), NCKC(6), DTCK(6), CTCK(6),
      2  N, ICK, IH, IP, ICK2, IH2, IP2, TMCKL, TMHL, DTS, DTPS, IC,
      3  IRETRN, TMPL, NPRT, NENCK, NHIST
      4  , DTM1, DTM2, JLAM, JOMEGA, AMBDA, OMEGA, JGAMMA, GAMMA
```

Table 2

TABLE OF COMMON ZONE AND REGION VARIABLES FOR VARIOUS SUBROUTINES

(Each variable is a label and common of the form COMMON / /. For example, "COMMON/RC/R(1)." The zone variables have all been dimensioned in COMSIZ.)

	EXEC	SPT	HYD	ROA	TSR	ROAEXP	TSREXP	CDR	ROADMP	ROB	ROC	RDI
RC/R(1)	X		X	X	X	X	X	X	X	X	X	X
UC/U(1)	X		X	X		X	X	X	X	X	X	X
TEMC/TEM(1)	X		X	X		X	X	X	X	X	X	X
TAMC/TAM(1)	X		X			X	X	X	X	X	X	X
VLC/VL(1)	X	X	X	X	X	X	X	X	X	X	X	X
PRC/PR(1)	X	X	X	X	X	X	X	X	X	X	X	X
EGC/EG(1)	X	X	X	X		X	X	X	X	X	X	X
KPC/KP(1)	X		X			X	X	X	X	X	X	X
KMC/KM(1)	X		X			X	X	X	X	X	X	X
DMASSC/DMASS(1)	X		X		X	X	X	X	X	X	X	X
DMESSC/DMESS(1)	X		X			X	X	X	X	X	X	X
TEMSQC/TEMSQ(1)	X		X			X	X	X	X	X	X	X
TEM3C/TEM3(1)	X		X			X	X	X	X	X	X	X
TEM4C/TEM4(1)	X		X			X	X	X	X	X	X	X
KDMC/KDM(1)	X					X	X	X	X	X	X	X
ELC/EL(1)	X	X				X	X	X	X	X	X	X
CKCOM/CKY(15)	X											
MATC/MAT(1)	X		X	X		X	X	X	X	X	X	X
QC/Q(1)	X		X	X		X	X	X	X	X	X	X
VLMC/VLM(1)	X	X	X	X	X	X	X	X	X	X	X	X
PRMC/PRM(1)	X	X	X	X		X	X	X	X	X	X	X
EGMC/EGM(1)	X	X	X	X		X	X	X	X	X	X	X
ELMC/ELM(1)	X	X				X	X	X	X	X	X	X
SUM2C/SUM2(15)	X											
THETAC/THETA(1)								X	X	X	X	X
DC/D(1)								X	X	X	X	X
DKDMPC/DKDMP(1)								X	X	X	X	X
DKDMMC/DKDMM(1)								X	X	X	X	X
SIGC/SIG(1)								X	X	X	X	X
CAPCC/CAPC(1)								X	X	X	X	X
HC/H(1)								X	X	X	X	X
CAPKC/CAPK(1)								X	X	X	X	X
GC/G(1)								X	X	X	X	X
CAPJC/CAPJ(1)								X	X	X	X	X
CTHSUM/THSUM(15)								X				
CTHSMM/THSMM(15)								X				

Table 2 (cont'd)

	ROD	ROE	TSRIMP	PFR	HIST	ECHECK	PROUT	C2R	GTVARE
RC/R(1)	X	X	X	X	X		X	X	
UC/U(1)	X	X	X		X	X	X	X	
TEMC/TEM(1)	X	X	X	X	X		X	X	X
TAMC/TAM(1)	X	X	X		X			X	
VLC/VL(1)	X	X	X		X		X	X	X
PRC/PR(1)	X	X	X		X		X	X	
EGC/EG(1)	X	X	X		X	X	X	X	
KPC/KP(1)	X	X	X		X			X	
KMC/KM(1)	X	X	X		X			X	
DMASSC/DMASS(1)	X	X	X		X	X	X	X	
DMESSC/DMESS(1)	X	X	X		X			X	
TEMSQC/TEMSQ(1)	X	X	X		X			X	
TEM3C/TEM3(1)	X	X	X		X			X	
TEM4C/TEM4(1)	X	X	X		X			X	
KDMC/KDM(1)	X	X	X		X			X	
ELC/EL(1)	X	X	X	X	X			X	
CKCOM/CKY(15)				X	X	X			
MATC/MAT(1)	X	X	X		X		X	X	X
QC/Q(1)	X	X	X		X		X	X	
VLMC/VLM(1)	X	X	X		X			X	
PRMC/PRM(1)	X	X	X		X			X	
EGMC/EGM(1)	X	X	X		X	X		X	
ELMC/ELM(1)	X	X	X	X	X			X	
SUM2C/SUM2(15)					X	X		X	
THETAC/THETA(1)	X	X	X						
DC/D(1)	X	X	X						
DKDMPC/DKDMP(1)	X	X	X						
DKDMMC/DKDMM(1)	X	X	X						
SIGC/SIG(1)	X	X	X						
CAPCC/CAPC(1)	X	X	X						
HC/H(1)	X	X	X						
CAPKC/CAPK(1)	X	X	X						
GC/G(1)	X	X	X						
CAPJC/CAPJ(1)	X	X	X						
CTHSUM/THSUM(15)				X					
CTHSMM/THSMM(15)				X					

SUBROUTINE DESCRIPTION

The Executor section of HAROLD consists of the following decks. A check mark on left side of deck number means the deck is not present, or modified in FORTRAN version.

1. COMSIZ
2. EMAIN
3. EXEC
✓4. Dummy CLNUP in FORTRAN
5. REOST
✓6. ESTAB (dummy ESTAB in FORTRAN)
7. FORMS (not present in FORTRAN)
8. SFT
9. HYD
10. ROA[h]
11. REGSR
12. RGSRFN*
13. ZONSR
14. ZNSRFN*
15. TSR[h]
16. JIT[h]
17. ROAEXP[e]
18. TSREXP[e]
19. CDR[i,e]
20. ROAIMP[i]
21. ROB[i]
22. ROC[i]
23. RDI[i]
24. ROD[i]
25. ROE[i]
26. TSRIMP[i]
27. POR
28. PPR
29. HIST
30. ECHECK
31. PROUT

32. COUT1*)
 .)
 .) RAND version only
 .)
 COUT25*)

33. CZR

34. PET

35. PBOUND*

RBOUND*

36. PEK

37. FINDC

38. ANEOS

39. FP100x

FE100x

FK100x

40. GETVAR

41. GTVRTB

42. IKAERR

43. ALIBI

The actual count of these subroutines in any given job will depend on the following:

1. What version - RAND or FORTRAN.
2. What type of radiation, if any.
3. What kind of source functions, analytic and/or step, zone and/or region, if any.
4. What kind of boundary conditions, analytic and/or step, minimum and/or maximum, if any.
5. What kind and how many equations of state are involved.

COMSIZ must occur first. ALIBI must occur last. Those subroutines indicated with an "h" are used only for hydrodynamics only calculations. Those indicated with an "e" are used only for explicit radiation. Those indicated with an "i" are used only for implicit radiation. Those which are not required may be removed from the object deck if more storage space is required for equations of state.

Those subroutines indicated by an "*" are special purpose subroutines which need be included only if they are required. Dummy entry points for all these routines are included in ALIBI.

1. COMSIZ

COMSIZ exists to give the user control over the amount of storage devoted to zone variables. SIZE is a name in COMSIZ which is defined as follows:

SIZE EQU 202

This EQU pseudo operation results in all zone variables being dimensioned 202, which permits 200 zones (storage must be allowed for boundary conditions at $j=-\frac{1}{2}$ and $j=jmax+\frac{1}{2}$). If more storage space is required for equations of state and the problem does not have 200 zones, SIZE may be equivalenced to the number of zones in the problem plus two. 220 storage cells are saved by reducing the value of SIZE by ten.

COMSIZ has a second variable, SIZEI, which is defined similarly to SIZE and is used to control the amount of storage allocated to variables used only by implicit radiation. For problems using implicit radiation,SIZEI should be equivalenced to the same number that SIZE is equivalenced to. For hydrodynamics only or explicit radiation problems it may be equivalenced to 0. 100 storage cells are saved by reducing the value of SIZEI by ten. For explicit radiation SIZEE is used to control the amount of storage allocated to variables used only in explicit problems. This variable should be equivalenced to SIZE. For hydro only problems it may be equivalenced to zero. For implicit problems SIZE, SIZEE and SIZEI are equal. The hierarchy then is as follows:

hydro only $0 < SIZE \leq 202$, SIZEE = SIZEI = 0

explicit only $0 < SIZE \leq 202$, SIZEE = SIZE, SIZEI = 0

implicit only $0 < SIZE \leq 202$, SIZEI = SIZEE = SIZE

COMSIZ also contains the conversion factors used by the COUT routines and the formats used by PROUT for RAND version.

This subroutine must occur first in the Executor deck as it defines the size of the control sections for zone variables. Also other subroutines have dummy control sections dimensioned 1.

```
$IBFTC COSIZE
      COMMON /RC/ R(202)
      COMMON /UC/ U(202)
      COMMON /TEMC/ TEM(202)
      COMMON /TAMC/ TAM(202)
      COMMON /VLC/ VL(202)
      COMMON /PRC/ PR(202)
      COMMON /EGC/ EG(202)
      COMMON /KPC/ KP(202)
      COMMON /KMC/ KM(202)
      COMMON /DMASSC/ DMASS(202)
      COMMON /DMESSC/ DMESS(202)
      COMMON /TEMSQC/ TEMSQ(202)
      COMMON /TEM3C/ TEM3(202)
      COMMON /TEM4C/ TEM4(202)
      COMMON /KDMC/ KDM(202)
      COMMON /ELC / EL(202)
      COMMON /MATC/ MAT(202)
      COMMON /ELMC/ ELM(202)
      COMMON /PRMC/ PRM(202)
      COMMON /EGMC/ EGM(202)
      COMMON /VLMC/ VLM(202)
      COMMON /QC/ Q(202)
      COMMON /THETAC/ THETA(202)
      COMMON /DC/ D(202)
      COMMON /DKDMPC/ DKDMP(202)
      COMMON /DKDMMC/ DKDMM(202)
      COMMON /SIGC/ SIG(202)
      COMMON /CAPCC/ CAPC(202)
      COMMON /HC/ H(202)
      COMMON /CAPKC/ CAPK(202)
      COMMON /GC/ G(202)
      COMMON /CAPJC/ CAPJ(202)
      END
```

2A. EMAIN (RAND version)

EMAIN is the deck in which execution of the Executor portion of HAROLD begins. It is also the entry point for the Executor. It determines from S.SLOC+4* the address of the first location not used by the program and establishes this location as the first location of the tabular equation of state coefficient table. It also determines from S.SLOC+3 the number of cells required for I/O buffers and from this it calculates the number of cells available for this coefficient table. This number is stored as LIMIT. It then calls EXEC.

*IBM Systems reference library form C28-6334, 1963, p. 59.

2B. EMAIN (FORTRAN)

C and LIMIT are dimensioned according to user specification as in GMAIN (FORTRAN).

```
$IBFTC EMAIN    REF
      DIMENSION C(3400)
      LIMIT = 3400
      CALL EXEC(C,LIMIT)
      CALL EXIT
      END
```

3. EXEC(C,LIMIT)

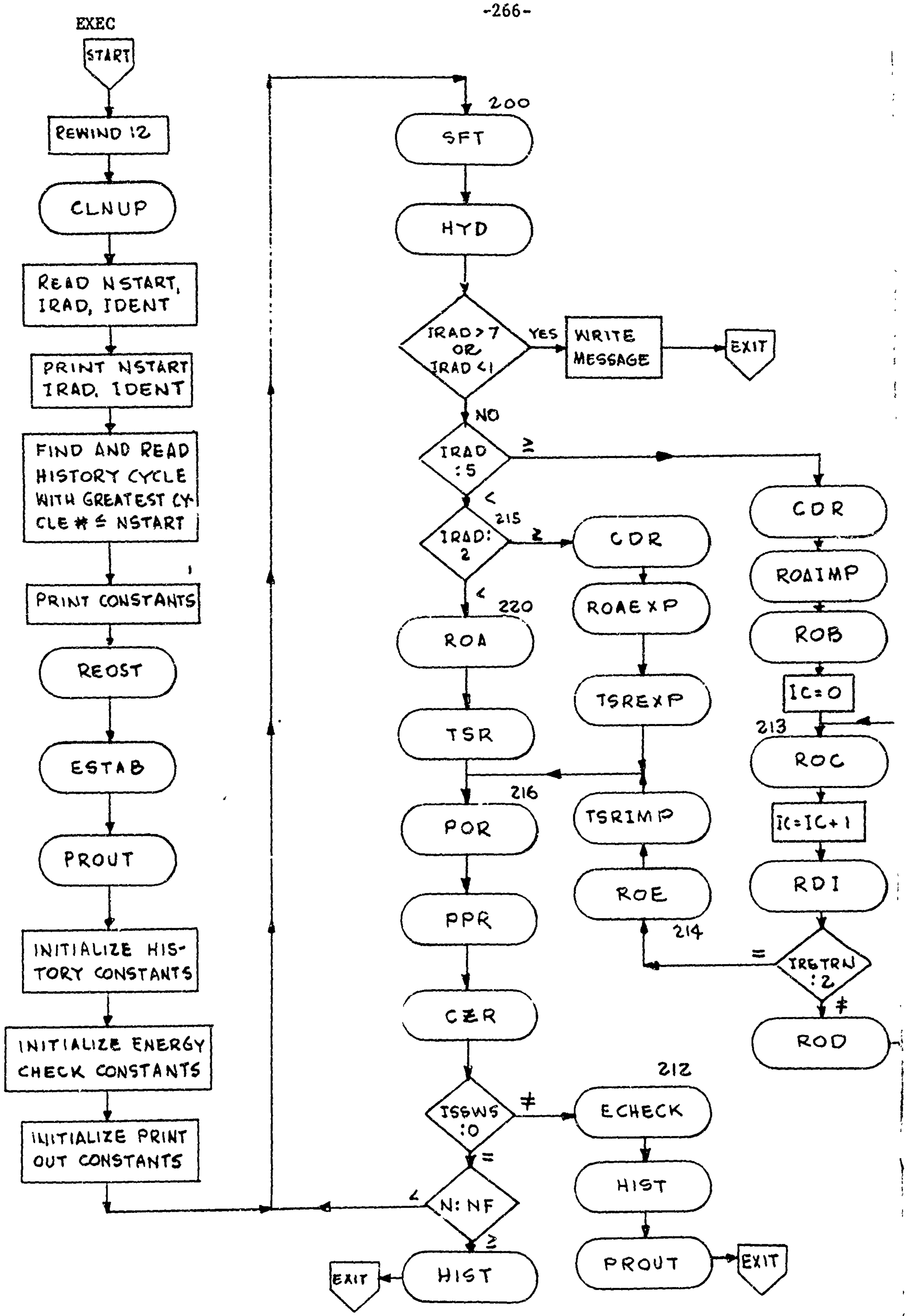
EXEC is the main controlling routine of the Executor. It reads the problem from the history tape and controls the cycle by cycle execution of the problem until cycle NF is reached or until an interval timer overflow occurs.

```
$IBFTC EXEC     REF
       SUBROUTINE EXEC(C,LIMIT)
      DIMENSION IDENT(10)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2F/ GROUPS TO BE PLACED HER(
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HER
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
      REWIND 12
       CALL CLNUP(C,ISSW5)
       READ 7004, NSTART,IRAD,IDENT
 7004  FORMAT (2I6,10A6)
       PRINT 7005, NSTART, IRAD, IDENT
 7005  FORMAT (1H1,3HNS=I6,2X,5HIRAD=I6,10A6)
    2 READ (12) J
       BACKSPACE 12
       IF(J.EQ.123456) GO TO 1
      READ  (12) NREG,JMAX,NRSRCE,NZSRCE,NEMIN,NEMAX,NKMIN,NKMAX,NPMIN,
     1 NPMAX,NTMIN,NTMAX,NUMIN,NUMAX,DT,DTP,DELTA,REGNO,N,NF,JZ,DRC,
     2 Z1,Z2,X1,X2,X3,X4,X5,X6,JO,JOM,JOS,JL,JSTAR,JHAT,UNCGS,UNMKS,
     3 TM,RMIN,RMAX
       JMAX2=JMAX+2
      READ  (12) (R(I),U(I),TEM(I),TAM(I),VL(I),VLM(I),PR(I),PRM(I),
     1 EG(I),EGM(I),KP(I), KM(I),DMASS(I),DMESS(I), TEMSQ(I),TEM3(I),
     2 TEM4(I),KDM(I),FL(I),ELM(I),MAT(I),G(I),I=1,JMAX2)
       READ (12)(RRG(I),JREG(I),C1(I),C2(I),C3(I),C4(I),C5(I),E0(I),
     1 CKY(I),SUM2(I),I=1,15),MEOS,IDEOS
      READ  (12) (NDH(I),NHC(I),NDP(I),NPC(I),NDCK(I),NCKC(I),EMIN(I),
     1 EMAX(I),KMIN(I),KMAX(I),PMIN(I),PMAX(I),TMIN(I),TMAX(I),UMIN(I),
     2 UMAX(I),TEMIN(I),TEMAX(I),TKMIN(I),TKMAX(I),TPMIN(I),TPMAX(I),
     3 TTMIN(I),TTMAX(I),TUMIN(I),TUMAX(I),DTH(I),CTH(I),DTPR(I),CTP(I)
```

```
    4 DTCK(I),CTCK(I),I=1,6)
      READ  (12) ((ERS(I,K),ES(I,K),TMRS(I,K),TMS(I,K),I=1,6),RS(K),
     1 JS(K),NRS(K),NZS(K),K=1,10)
       IF(N.GE.NSTART) GO TO 1
       GO TO 2
    1 PRINT 7010, (C1(I),C2(I),C3(I),C4(I),C5(I),I=1,NREG)
 7010 FORMAT (1H0 6X 2HC1 10X 2HC2 10X 2HC3 10X 2HC4 10X 2HC5
     1  /(1H 5E12.4))
      PRINT 7011,J0,JOS,JOM,DRC,Z1,Z2,JL,JHAT,JSTAR,X1,X2,X3,X4,X5,X6
 7011 FORMAT (1H0 4X 2HJ0 3X 3HJOS 3X 3HJOM 9X 3HDRC / 1H  3I6,E12.4 /
     1  1H0 6X 2HZ1 10X 2HZ2 8X 2HJL 4X 4HJHAT 3X 5HJSTAR / 1H 2E12.4,
     2  I6, 2I8 / 1H0 6X 2HX1 10X
     3  2HX2 10X 2HX3 10X 2HX4 10X 2HX5 10X 2HX6 / 1H  6E12.4)
       CALL REOST(C,LIMIT)
       CALL ESTAB
       CALL PROUT(C)
       DMESS(1)=DMASS(2)/2.
       DMESS(JMAX+1)=DMASS(JMAX+1)/2.
      NPRT=NDP(1)
      NENCK=NDCK(1)
      NHIST=NDH(1)
       IF(NDP(1).NE.0) GO TO 90
       DO 81 I=1,6
       IF(CTP(I).GT.TM) GO TO 82
   81  CONTINUE
       I=6
   82  IP2=I
       IF(I.EQ.1) GO TO 84
       TMPL=CTP(I-1)
       GO TO 86
   84  TMPL=0.
   86  IF(TMPL+DTPR(I)*(1.+1.E-7).GT.TM) GO TO 140
       TMPL=TMPL+DTPR(I)
       GO TO 86
90    IF (NPRT.GT.N) GO TO 140
100   IF (NPRT.GE.NPC(1)) GO TO 101
       I=1
       GO TO 120
 101 I=2
102   IF (NPRT.LT.NPC(I).AND.NPRT.GE.NPC(I-1)) GO TO 120
      IF (I.GE.6) GO TO 120
      I=I+1
      GO TO 102
120   NPRT=NPRT+NDP(I)
      GO TO 90
 140   IF(NDCK(1).NE.0) GO TO 149
       DO 141 I=1,6
       IF(CTCK(I).GT.TM) GO TO 142
 141   CONTINUE
       I=6
 142   ICK2=I
       IF(I.EQ.1) GO TO 144
```

```
      TMCKL=CTCK(I-1)
      GO TO 146
 144  TMCKL=0.
 146  IF(TMCKL+DTCK(I)*(1.+1.E-7).GT.TM) GO TO 180
      TMCKL=TMCKL+DTCK(I)
      GO TO 146
 149 IF (NENCK.GT.N) GO TO 180
150  IF (NENCK.GE.NCKC(1)) GO TO 151
      I=1
      GO TO 160
 151 I=2
152  IF (NENCK.LT.NCKC(I). AND.NENCK.GE.NCKC(I-1)) GO TO 160
     IF (I.GE.6) GO TO 160
     I=I+1
     GO TO 152
160  NENCK=NENCK+NDCK(I)
     GO TO 140
 180  IF(NDH(1).NE.0) GO TO 189
      DO 181 I=1,6
      IF(CTH(I).GT.TM) GO TO 182
 181  CONTINUE
     I=6
 182  IH2=I
      IF(I.EQ.1) GO TO 184
      TMHL=CTH(I-1)
      GO TO 186
 184  TMHL=0.
 186  IF(TMHL+DTH(I)*(1.+1.E-7).GT.TM) GO TO 200
      TMHL=TMHL+DTH(I)
      GO TO 186
 189 IF (NHIST.GT.N) GO TO 200
     IF (NHIST.GE.NHC(1)) GO TO 191
      I=1
      GO TO 190
 191 I=2
 192 IF (NHIST.LT.NHC(I).AND.NHIST.GE.NHC(I-1)) GO TO 190
     IF (I.GE.6) GO TO 190
     I=I+1
      GO TO 192
190  NHIST=NHIST+NDH(I)
     GO TO 180
 200 CALL SFT
     CALL HYD(C)
      IF(IRAD.GT.7.OR.IRAD.LT.1) GO TO 9999
      IF(IRAD.LT.5) GO TO 215
      CALL CDR(C)
      CALL ROAIMP(C)
      CALL ROB(C)
      IC=0
```

```
 213  CALL ROC(C)
      IC=IC+1
      CALL RDI(C)
      IF(IRETRN.EQ.2) GO TO 214
      CALL ROD(C)
      GO TO 213
 214  CALL ROE(C)
      CALL TSRIMP(C)
      GO TO 216
 215 IF(IRAD.LT.2) GO TO 220
     CALL COR(C)
      CALL ROAEXP(C)
      CALL TSREXP(C)
      GO TO 216
 220  CALL ROA(C)
      CALL TSR(C)
 216 CALL POR
      CALL PPR(C)
      CALL CZR(C)
      IF(ISSW5.NE.0) GO TO 212
     IF (N.LT.NF) GO TO 200
     CALL HIST
     CALL EXIT
 212 CALL ECHECK
     CALL HIST
      CALL PROUT(C)
     CALL EXIT
9999 PRINT 7999
7999 FORMAT(26H0ILLEGAL RAD. INDEX GIVEN.      )
      CALL EXIT
     END
```


EXEC
START
REWIND 12
CLNUP
READ NSTART, IRAD, IDENT
PRINT NSTART IRAD, IDENT
FIND AND READ HISTORY CYCLE WITH GREATEST CYCLE # ≤ NSTART
PRINT CONSTANTS
REOST
ESTAB
PROUT
INITIALIZE HISTORY CONSTANTS
INITIALIZE ENERGY CHECK CONSTANTS
INITIALIZE PRINT OUT CONSTANTS
200
SFT
HYD
IRAD>7 OR IRAD<1
YES
WRITE MESSAGE
EXIT
NO
IRAD :5
≥
<
215
IRAD: 2
≥
<
220
CDR
ROAEXP
TSREXP
TSRIMP
ROE
214
CDR
ROAIMP
ROB
IC=0
213
ROC
IC=IC+1
RDI
IRGTRN :2
=
≠
ROD
ROA
TSR
216
POR
PPR
CZR
ISSWS :0
≠
=
212
ECHECK
HIST
PROUT
EXIT
N: NF
<
≥
HIST
EXIT

4A. CLNUP(I,ISSW5) (RAND Version)

CLNUP is designed to prevent loss of any calculations when an interval timer overflow occurs. If I is 0, ISSW5 is set to 0 and is set non-zero when the interval timer overflows. The interval timer is then reset to allow 1 more minute of computation. ISSW5 is checked in EXEC at the end of every cycle. If it is non-zero, a history edit is taken and a print-out occurs. Then EXIT is called.

4B. In FORTRAN version CLNUP is a dummy subroutine.

```
$IBFTC CLNUP   REF
      SUBROUTINE CLNUP (I,J)
      J=0
      RETURN
      END
```

5. REOST(C,LIMIT)

REOST reads the interpolation coefficients from the equation of state tape prepared by TABCOE. The T's, ρ's and C's are stored in the C array as follows:

T's for P of 1st eq. of state encountered on the tape
ρ's for P of 1st eq. of state encountered on the tape
C's for P of 1st eq. of state encountered on the tape
T's for E of 1st eq. of state encountered on the tape
ρ's for E of 1st eq. of state encountered on the tape
C's for E of 1st eq. of state encountered on the tape
T's for K of 1st eq. of state encountered on the tape
ρ's for K of 1st eq. of state encountered on the tape
C's for K of 1st eq. of state encountered on the tape
T's for P of 2nd eq. of state encountered on the tape
.
.
.
C's for K of last eq. of state encountered on the tape

Four tables are constructed for locating numbers in the C table. $IORDER_i$ contains the identification number of the INO^{th} equation of

state read from the tape. IBEGT(i,j) contains the address of the first T of the ITABth equation of the INOth equation of state. ITAB = 1, 2 or 3 for P, E and K respectively. IBEGV(i,j) and IBEGC(i,j) are the first locations of the corresponding V and coefficient C. This subroutine is identical with the GENERATE program subroutine, see p. 159 for flow chart.

```
$IBFTC REOST   REF
      SUBROUTINE REOST(C,LIMIT)
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
       DIMENSION C(1)
       IF(MEOS.EQ.0) RETURN
      REWIND 8
      INO=0
   15 IBEGT(1,1)=1
      DO 110 IT=1,100
      READ(8) IEOS
      IF(IEOS.GT.0 )  GO TO 10
      PRINT 7000,INO,MEOS
 7000 FORMAT (61H1    END OF EOS TAPE ENCOUNTERED, NO. OF EOS FOUND AN
     1D READ = I4, 36H      NO. OF EOS NEEDED IN THIS JOB = I4)
      RETURN
   10 BACKSPACE 8
      READ (8) IEOS,ITABNO,NOTS,NOVS
      BACKSPACE 8
      DO 18 I=1,6
      IF(IEOS.EQ.IDEOS(I))  GO TO 20
   18 CONTINUE
      GO TO 100
   20 INO=INO+1
      IORDER(INO)= IEOS
      DO 107 ITAB=1,3
      READ (8) IEOS,ITABNO,NOTS,NOVS
      IBEGV(ITAB,INO)=IBEGT(ITAB,INO)+NOTS
      ITC=IBEGT(ITAB,INO)
      ITS=ITC+NOTS-1
      IVC=ITS+1
      IVS=IVC+NOVS-1
       IF(IVS.GT.LIMIT) GO TO 999
      READ (8)            (C(I),I=ITC,ITS),(C(I),I=IVC,IVS)
C
C     SKIP NEXT RECORD ON EOS TAPE
C
      READ(8)
      IBEGC(ITAB,INO) =IBEGV(ITAB,INO)+NOVS
      NOCT=NOTS/2
      NOCV=NOVS/2
      ITOTC= NOCT*9*NOCV
```

```
      ICC = IBEGC(ITAB,INO)
      ICS=ICC+ITOTC-1
       IF(ICS.GT.LIMIT) GO TO 999
      READ (8) (C(I),I=ICC,ICS)
      IBEGT(ITAB+1,INO)= IBEGC(ITAB,INO)+ITOTC
  107 CONTINUE
      IF(INO.EQ.MEOS)  GO TO 120
      GO TO 110
C
C     SKIP NEXT 12 RECORDS - TO BEGINNING OF NEXT EOS INFORMATION
C
  100 DO 105 ISKIP =1,12
  105 READ (8)
  110 CONTINUE
  120 REWIND 8
      RETURN
  999 PRINT 7001
 7001 FORMAT(47HOEOS TABLES REQUESTED EXCEED AVAILABLE STORAGE.  )
       CALL EXIT
      END
```

6. ESTAB (RAND version only)

ESTAB reads the output description deck and constructs a table, ITAB, of functions to be printed as follows:

$ITAB_{1,j}$ is the BCD name of the jth function to be printed

$ITAB_{2,j}$ is the conversion factor for the jth function to be printed

$ITAB_{3,j}$ is the number of significant figures of the jth function to be printed

$ITAB_{4,j}$ is the function number of the jth function to be printed

It then calls FORMS to establish the FORMAT statements necessary. Subroutine ESTAB is a dummy in the FORTRAN version.

```
$IBFTC ESTAB   REF
      SUBROUTINE ESTAB
      RETURN
      END
```

7. FORMS (RAND version only)

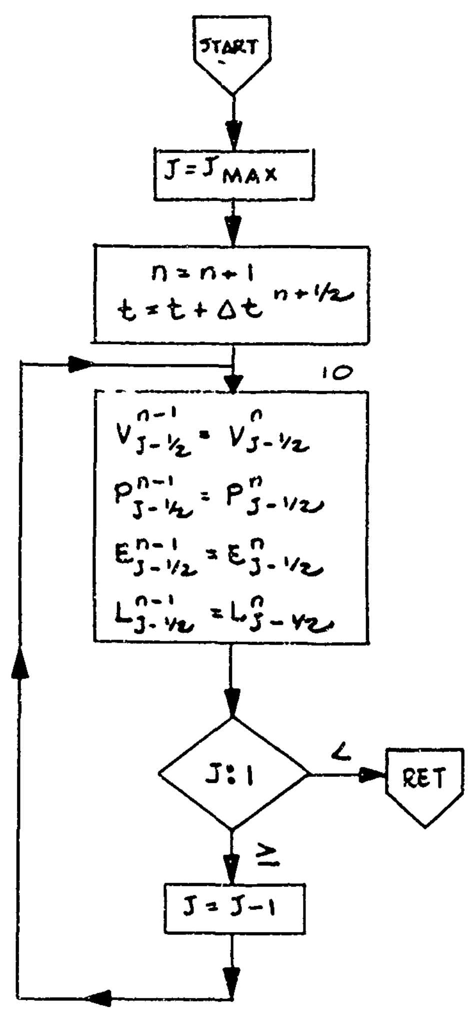
FORMS is a MAP subroutine which uses the table ITAB, constructed by ESTAB, to construct the necessary formats for output by PROUT.

8. SFT

At the beginning of cycle n+1, SFT moves those variables calculated during cycle n, which must be saved, to the storage for cycle n-1. It then sets n = n+1.

```
$IBFTC SFT      REF
      SUBROUTINE SFT
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HE
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HE
      J=JMAX
      N=N+1
      TM=TM+DTP
   10 VLM(J+1)=VL(J+1)
      PRM(J+1)=PR(J+1)
      EGM(J+1)=EG(J+1)
      ELM(J+1)=EL(J+1)
      IF (J.LT.1) RETURN
      J=J-1
      GO TO 10
      END
```

SFT



9. HYD(C)

HYD is called by EXEC. It calculates R, U, V and Q for zones 1 through $\hat{j}$.

HYD also governs boundary conditions. It is possible to establish boundary conditions at $j \simeq 0$ for U, P, T, E and K (but not simultaneously). However, RMIN must be greater than zero in order to fix any other minimum criteria, since RMIN = 0 implies an origin at j = 0 in radial or cylindrical symmetry for which both UMIN and RMIN are identically zero, and no other variables need be defined. When RMIN $\neq$ 0 the following combinations of variables are permitted

(R and U), (R and P), (R and T),
(R and U and P), (R and U and T), (R and T and (E or K)), or
((R and U and T) and (E or K)).

When $\hat{j}$ = JMAX, HYD determines the value of the right hand boundary conditions (maximum j) if any. The following combinations are permissible

U, P (step function), P (analytic from PBOUND), T singly
(T and (E or K)), (P(analytic) and T)), (P(analytic) and
T and (E or K)).

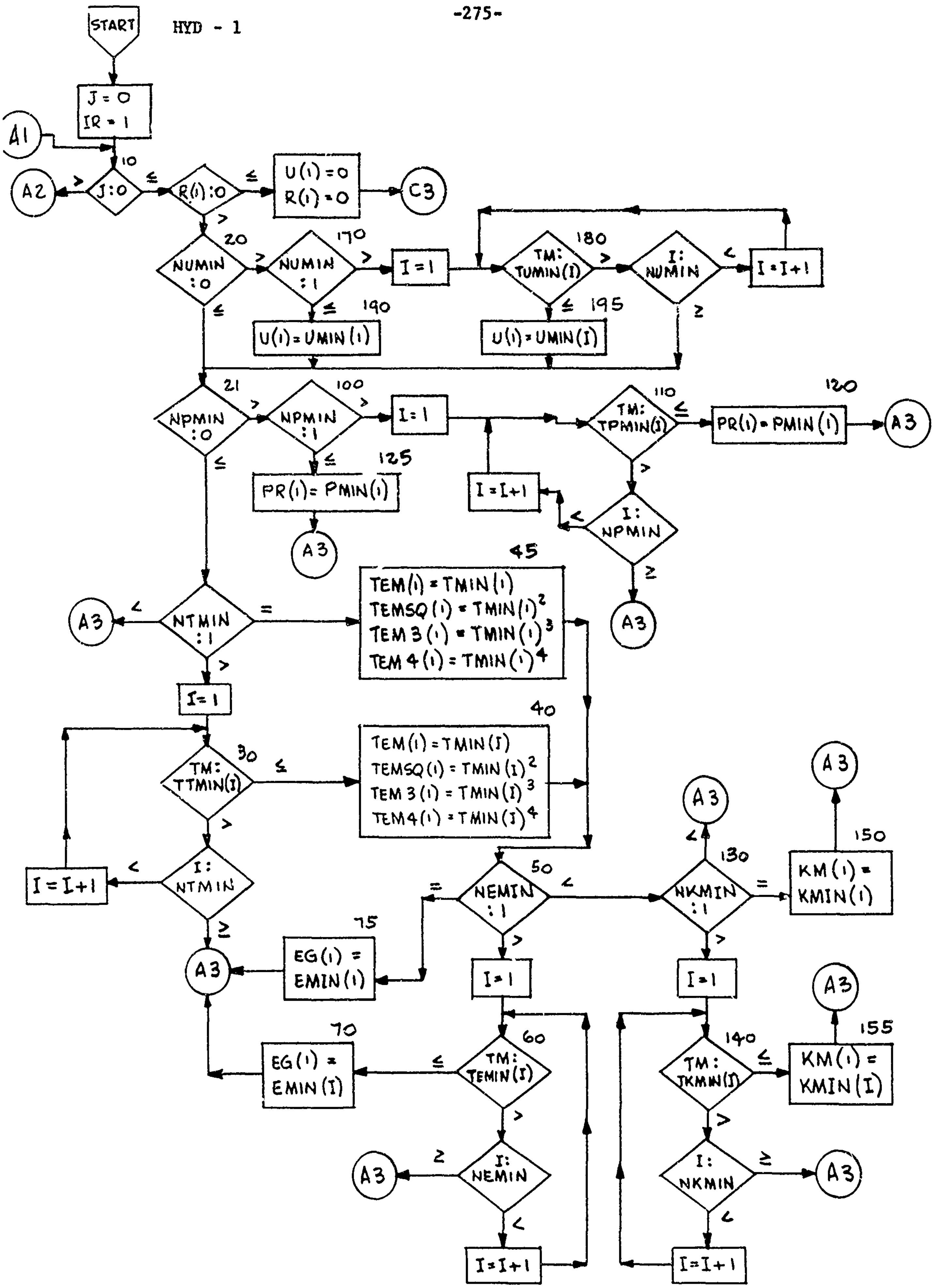
```
$IBFTC HYD      REF
      SUBROUTINE HYD(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
      J=0
      IR=1
   10 IF (J.GT.0) GO TO 200
      IF (R(1).GT.0.) GO TO 20
      U(1)=0.
      R(1)=0.
      GO TO 440
   20 IF (NUMIN.GT.0) GO TO 170
   21 IF (NPMIN.GT.0) GO TO 100
      IF (NTMIN.LE.0) GO TO 420
      IF (NTMIN.LE.1) GO TO 45
      I=1
```

```
 30 IF (TM.LE.TTMIN(I)) GO TO 40
    IF (I.GE.NTMIN) GO TO 420
    I=I+1
    GO TO 30
 40 TEM(1)=TMIN(I)
     TEMSQ(1)=TEM(1)**2
     TEM3(1)=TEMSQ(1)*TEM(1)
     TEM4(1)=TEMSQ(1)*TEMSQ(1)
    GO TO 50
 45 TEM(1)=TMIN(1)
     TEMSQ(1)=TEM(1)**2
     TEM3(1)=TEMSQ(1)*TEM(1)
     TEM4(1)=TEMSQ(1)*TEMSQ(1)
 50 IF (NEMIN.LE.0) GO TO 130
    IF (NEMIN.LE.1) GO TO 75
    I=1
 60 IF (TM.LE.TEMIN(I) ) GO TO 70
    IF (I.GE.NEMIN) GO TO 420
    I=I+1
    GO TO 60
 70 EG(1)=EMIN(I)
     GO TO 420
 75 EG(1)=EMIN(1)
    GO TO 420
100 IF (NPMIN.LE.1) GO TO 125
    I=1
110 IF (TM.LE.TPMIN(I) ) GO TO 120
    IF (I.GE.NPMIN) GO TO 420
    I=I+1
    GO TO 110
120 PR(1)=PMIN(I)
    GO TO 420
125 PR(1)=PMIN(1)
    GO TO 420
130 IF (NKMIN.LE.0) GO TO 420
    IF (NKMIN.LE.1) GO TO 150
    I=1
140 IF (TM.LE.TKMIN(I) ) GO TO 155
    IF (I.GE.NKMIN) GO TO 420
    I=I+1
    GO TO 140
150 KM(1)=KMIN(1)
     GO TO 420
155 KM(1)=KMIN(I)
     GO TO 420
170 IF (NUMIN.LE.1) GO TO 190
    I=1
180 IF (TM.LE.TUMIN(I)) GO TO 195
    IF (I.GE.NUMIN) GO TO 21
    I=I+1
    GO TO 180
190 U(1)=UMIN(1)
     GO TO 21
```

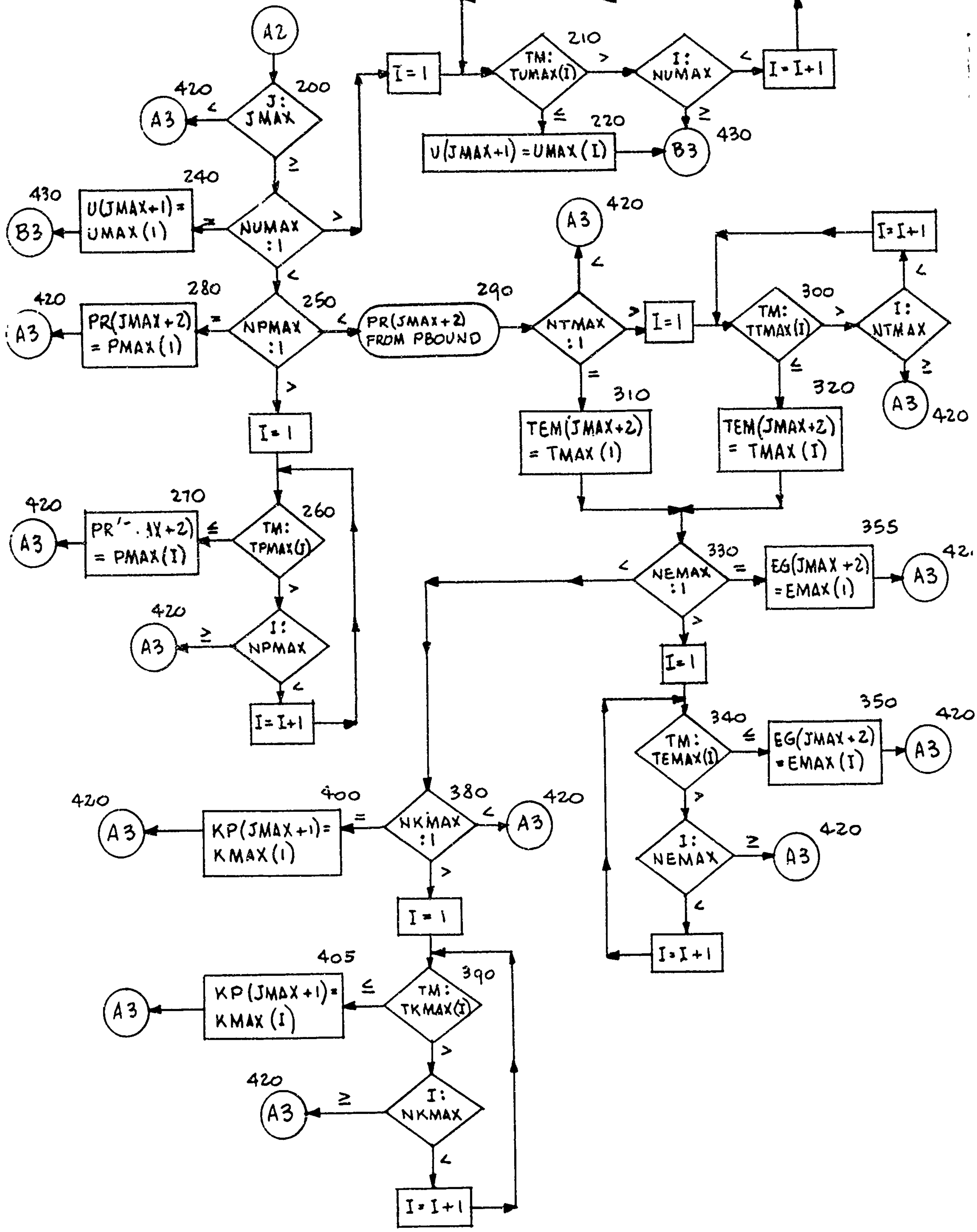
```
195 U(1)=UMIN(I)
    GOTO 21
200 IF (J.LT.JMAX) GO TO 420
    IF (NUMAX.LE.0) GO TO 250
    IF (NUMAX.LE.1) GO TO 240
    I=1
210 IF (TM.LE.TUMAX(I)) GO TO 220
    IF (I.GE.NUMAX) GO TO 430
    I=I+1
    GO TO 210
220 U(JMAX+1)=UMAX(I)
    GO TO 430
240 U(JMAX+1)=UMAX(1)
    GO TO 430
250 IF (NPMAX.LE.0) GO TO 290
    IF (NPMAX.LE.1) GO TO 280
    I=1
260 IF (TM.LE.TPMAX(I) ) GO TO 270
    IF (I.GE.NPMAX) GO TO 420
    I=I+1
    GO TO 260
270 PR(JMAX+2)=PMAX(I)
    GO TO 420
280 PR(JMAX+2)=PMAX(1)
    GO TO 420
290 CALL PBOUND(TM,PR(JMAX+2))
    IF (NTMAX.LE.0) GO TO 420
    IF (NTMAX.LE.1) GO TO 310
    I=1
300 IF (TM.LE.TTMAX(I) ) GO TO 320
    IF (I.GE.NTMAX) GO TO 420
    I=I+1
    GO TO 300
310 TEM(JMAX+2)=TMAX(1)
    GO TO 330
320 TEM(JMAX+2)=TMAX(I)
330 IF (NEMAX.LE.0) GO TO 380
    IF (NEMAX.LE.1) GO TO 355
    I=1
340 IF (TM.LE.TEMAX(I) ) GO TO 350
    IF (I.GE.NEMAX) GO TO 420
    I=I+1
    GO TO 340
350 EG(JMAX+2)=EMAX(I)
     GO TO 420
355 EG(JMAX+2)=EMAX(1)
    GO TO 420
380 IF (NKMAX.LE.0) GO TO 420
    IF (NKMAX.LE.1) GO TO 400
    I=1
```

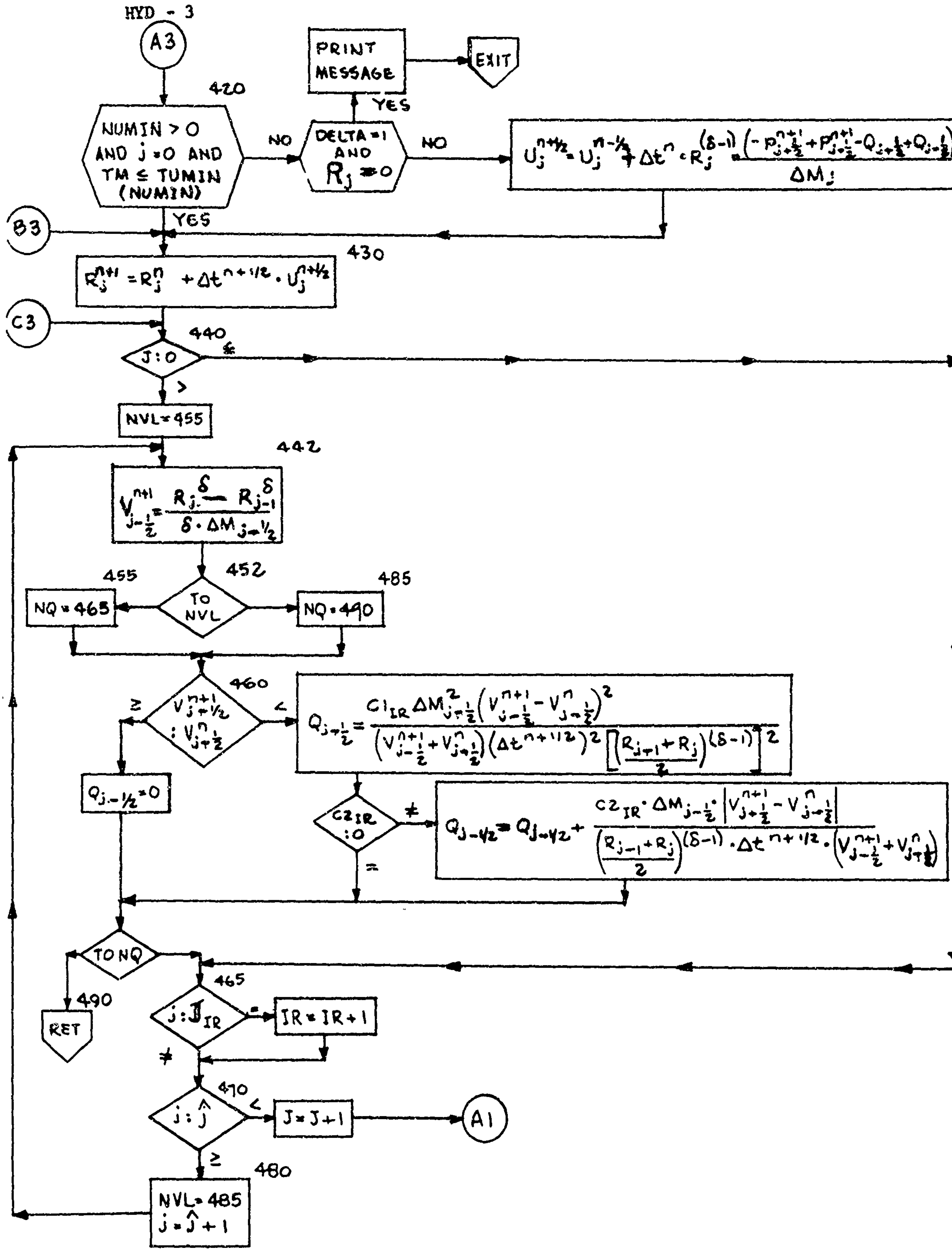
```
 390 IF (TM.LE.TKMAX(I) ) GO TO 405
     IF (I.GE.NKMAX) GO TO 420
     I=I+1
     GO TO 390
 400 KP(JMAX+1)=KMAX(1)
      GO TO 420
 405 KP(JMAX+1)=KMAX(I)
 420  IF(NUMIN.GT.0.AND.J.EQ.0.AND.TM.LE.TUMIN(NUMIN))GO TO 430
      IF(DELTA.EQ.1.AND.R(J+1).EQ.0.) PRINT 7000, J
      IF(DELTA.EQ.1.AND.R(J+1).EQ.0.) CALL EXIT
7000  FORMAT(22HOR IS 0 IN HYD IN ZONE  I6)
     U(J+1)=U(J+1)+DT*R(J+1)**(DELTA-1)*(-PR(J+2)+PR(J+1)-Q(J+2)+Q(J+1)
    1)/DMESS(J+1)
 430 R(J+1)=R(J+1)+DTP*U(J+1)
 440 IF (J.LE.0) GO TO 465
     ASSIGN 455 TO NVL
 442 IF (DELTA.LE.2) GO TO 445
     VL(J+1)= (R(J+1)-R(J))*(R(J+1)**2+R(J+1)*R(J)+R(J)**2)/
    1 DMASS(J+1)/3.
     GO TO 452
 445 IF (DELTA.LE.1) GO TO 450
     VL(J+1)= (R(J+1)-R(J))*(R(J+1)+R(J))/DMASS(J+1)/2.
     GO TO 452
 450 VL(J+1)=(R(J+1)-R(J))/DMASS(J+1)
452  GO TO NVL (455,485)
 455 ASSIGN 465 TO NQ
 460  IF(VL(J+1).GE.VLM(J+1)) GO TO 461
     Q(J+1)=C1(IR)* DMASS(J+1)**2*(VL(J+1)-VLM(J+1))**2/
    1 ((VL(J+1)+VLM(J+1))*DTP**2*(((R(J+1)+R(J))/2.)**(DELTA-1))**2)
      IF(C2(IR).EQ.0.) GO TO 462
      Q(J+1)=Q(J+1)+C2(IR)*DMASS(J+1)*ABS(VL(J+1)-VLM(J+1))/
    1   (((R(J+1)+R(J))/2.)**(DELTA-1)*DTP*(VL(J+1)+VLM(J+1)))
 462  GO TO NQ(465,490)
 461 Q(J+1)=0.
     GO TO NQ  (465,490)
 465 IF (J.NE.JREG(IR) ) GO TO 470
     IR=IR+1
470  IF (J.GE.JHAT) GO TO 480
     J=J+1
     GO TO 10
 480 ASSIGN 485 TO NVL
     J=JHAT+1
     GO TO 442
 485 ASSIGN 490 TO NQ
     GO TO 460
 490 RETURN
     END
```

HYD - 1


START
J = 0
IR = 1
A1
10
J:0
A2
R(1):0
U(1)=0
R(1)=0
C3
20
NUMIN :0
170
NUMIN :1
I=1
180
TM: TUMIN(I)
I: NUMIN
I=I+1
190
U(1)=UMIN(1)
195
U(1)=UMIN(I)
21
NPMIN :0
100
NPMIN :1
I=1
110
TM: TPMIN(I)
120
PR(1)=PMIN(1)
A3
125
PR(1)=PMIN(1)
I=I+1
I: NPMIN
45
NTMIN :1
TEM(1)=TMIN(1)
TEMSQ(1)=TMIN(1)²
TEM 3(1)=TMIN(1)³
TEM 4(1)=TMIN(1)⁴
I=1
40
30
TM: TTMIN(I)
TEM(1)=TMIN(I)
TEMSQ(1)=TMIN(I)²
TEM 3(1)=TMIN(I)³
TEM4(1)=TMIN(I)⁴
I: NTMIN
I=I+1
50
NEMIN :1
130
NKMIN :1
150
KM(1)= KMIN(1)
75
EG(1)= EMIN(1)
I=1
I=1
70
EG(1)= EMIN(I)
60
TM: TEMIN(I)
140
TM: TKMIN(I)
155
KM(1)= KMIN(I)
I: NEMIN
I: NKMIN
I=I+1
I=I+1

HYD - 2


A2
200
J: JMAX
420
A3
240
NUMAX :1
U(JMAX+1) = UMAX(1)
430
B3
I=1
210
TM: TUMAX(I)
I: NUMAX
I=I+1
220
U(JMAX+1) = UMAX(I)
B3
430
280
PR(JMAX+2) = PMAX(1)
250
NPMAX :1
PR(JMAX+2) FROM PBOUND
290
NTMAX :1
A3
420
I=1
300
TM: TTMAX(I)
I: NTMAX
I=I+1
310
TEM(JMAX+2) = TMAX(1)
320
TEM(JMAX+2) = TMAX(I)
A3
420
I=1
270
260
TM: TPMAX(I)
I: NPMAX
I=I+1
330
NEMAX :1
355
EG(JMAX+2) = EMAX(1)
I=1
340
TM: TEMAX(I)
350
EG(JMAX+2) = EMAX(I)
I: NEMAX
I=I+1
400
KP(JMAX+1) = KMAX(1)
380
NKMAX :1
I=1
405
KP(JMAX+1) = KMAX(I)
390
TM: TKMAX(I)
I: NKMAX
I=I+1


HYD - 3
A3
420
NUMIN > 0 AND j = 0 AND TM ≤ TUMIN (NUMIN)
NO
DELTA = 1 AND R_j = 0
YES
PRINT MESSAGE
EXIT
NO
$U_j^{n+1/2} = U_j^{n-1/2} + \Delta t^n \cdot R_j^{(\delta-1)} \cdot \frac{\left(-P_{j+\frac{1}{2}}^{n+1} + P_{j-\frac{1}{2}}^{n+1} - Q_{j+\frac{1}{2}} + Q_{j-\frac{1}{2}}\right)}{\Delta M_j}$
YES
B3
430
$R_j^{n+1} = R_j^n + \Delta t^{n+1/2} \cdot U_j^{n+1/2}$
C3
440
J : 0
>
NVL = 455
442
$V_{j-\frac{1}{2}}^{n+1} = \frac{R_j^{\delta} - R_{j-1}^{\delta}}{\delta \cdot \Delta M_{j-1/2}}$
455
452
485
NQ = 465
TO NVL
NQ = 490
460
≥
<
$V_{j+1/2}^{n+1} : V_{j+\frac{1}{2}}^{n}$
$Q_{j+\frac{1}{2}} = \frac{C1_{IR} \Delta M_{j+\frac{1}{2}}^2 \left(V_{j-\frac{1}{2}}^{n+1} - V_{j-\frac{1}{2}}^n\right)^2}{\left(V_{j-\frac{1}{2}}^{n+1} + V_{j+\frac{1}{2}}^n\right)\left(\Delta t^{n+1/2}\right)^2 \left[\left(\frac{R_{j+1}+R_j}{2}\right)^{(\delta-1)}\right]^2}$
$Q_{j-1/2} = 0$
$C2_{IR} : 0$
≠
=
$Q_{j-1/2} = Q_{j-1/2} + \frac{C2_{IR} \cdot \Delta M_{j-\frac{1}{2}} \cdot \left|V_{j+\frac{1}{2}}^{n+1} - V_{j-\frac{1}{2}}^n\right|}{\left(\frac{R_{j-1}+R_j}{2}\right)^{(\delta-1)} \cdot \Delta t^{n+1/2} \cdot \left(V_{j-\frac{1}{2}}^{n+1} + V_{j+\frac{1}{2}}^n\right)}$
TO NQ
490
RET
465
$j : J_{IR}$
=
IR = IR + 1
≠
470
<
$j : \hat{j}$
J = J + 1
A1
≥
480
NVL = 485
$j = \hat{J} + 1$

10. ROA(C)

ROA is called by EXEC. It calculates E, P and T for hydrodynamics only problems; i.e., for zones $j = 1, \hat{j}$.

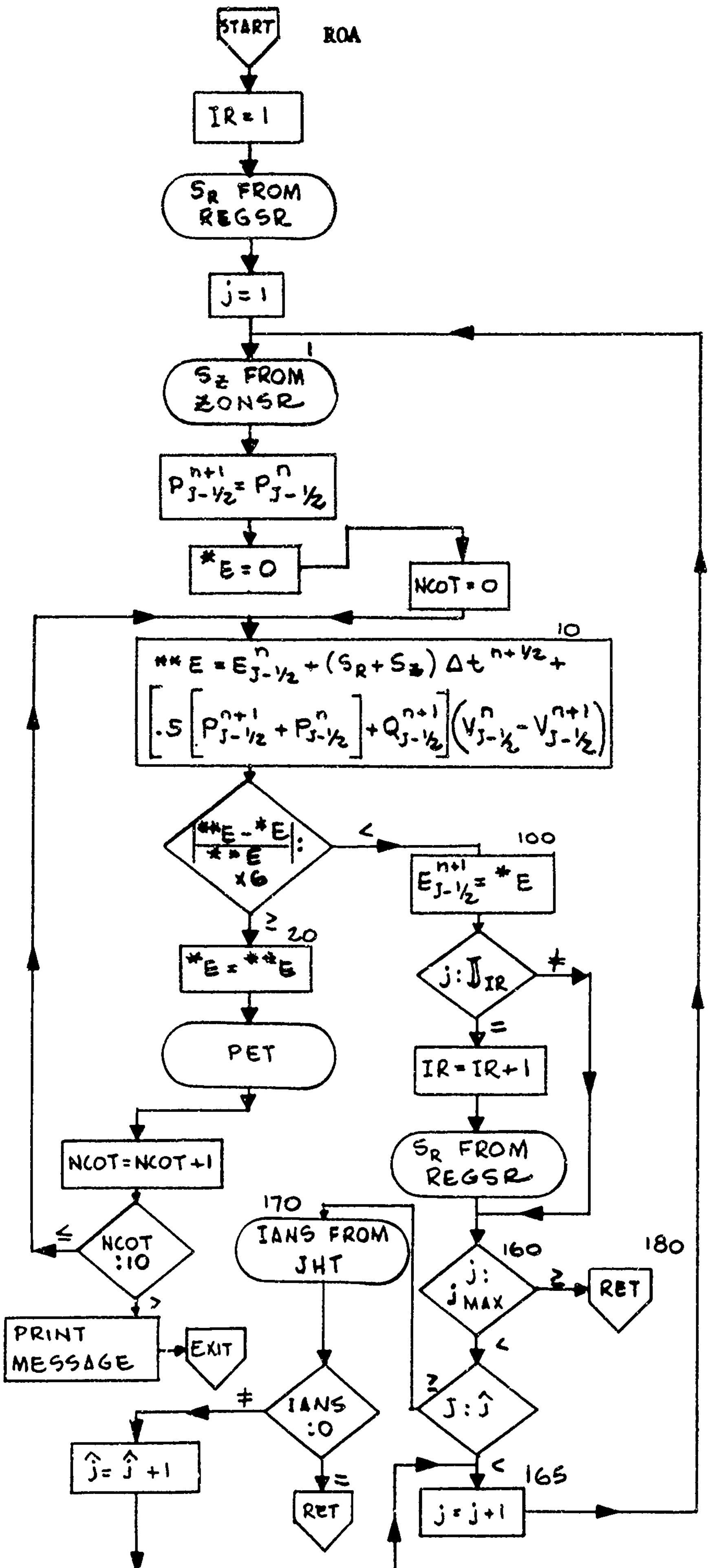
If Z2 is a velocity we use the deck JHTU.

If Z2 is a temperature we use the deck JHTT.

Each time we go thru ROA we test the appropriate condition against Z2 to see if j needs to be increased. If $TEM_{\hat{j}} \geq Z2$ (or $U_{\hat{j}} \geq Z2$) then $\hat{j} = \hat{j}+1$.

The energy is considered to have converged when $\Delta E \leq X6 \cdot E$.

```
$IBFTC ROA      REF
       SUBROUTINE ROA(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HE
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HE
      DIMENSION C(1)
       IR=1
       CALL REGSR(IR,SR)
       J=1
    1  CALL ZONSR(J,SZ)
       PR(J+1)=PRM(J+1)
       EX=C.
       NCOT=0
   10  ESS=EGM(J+1)+(SR+SZ)*DTP+((PR(J+1)+PRM(J+1))*.5+Q(J+1))
     1   *(VLM(J+1)-VL(J+1))
       IF(ABS((ESS-EX)/ESS).LT.X6) GO TO 100
   20  EX=ESS
       CALL PET(MAT(J+1),TEM(J+1),VL(J+1),PR(J+1),EX,J,C)
       NCOT=NCOT+1
       IF(NCOT.LE.10) GO TO 10
       PRINT 7000
 7CCC FORMAT (10HOROA LOOP.)
       CALL EXIT
  10C  EG(J+1)=EX
       IF(J.NE.JREG(IR)) GO TO 160
       IR=IR+1
       CALL RFGSR(IR,SR)
  160 IF(J.GE.JMAX) GO TO 180
       IF(J.GE.JHAT) GO TO 170
  165 J=J+1
       GO TC 1
  17C  CALL JHT(TEM(JHAT+1),U(JHAT),Z2,IANS)
       IF(IANS.EQ.0) RETURN
       JHAT=JHAT+1
       GO TC 165
  18C  RETURN
       END
```

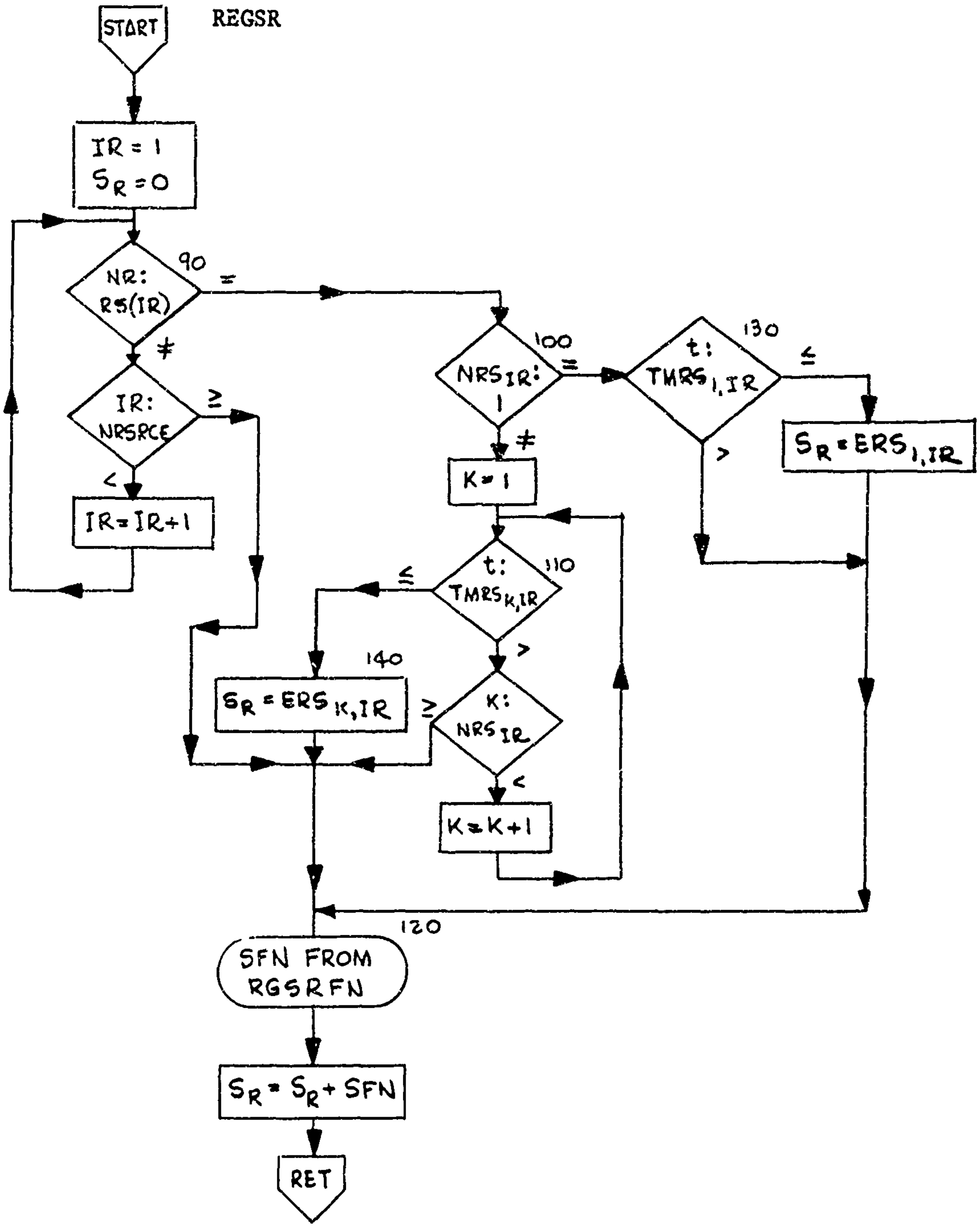

START
ROA
IR = 1
S_R FROM REGSR
j = 1
1
S_Z FROM ZONSR
$P^{n+1}_{J-1/2} = P^{n}_{J-1/2}$
*E = 0
NCOT = 0
10
$**E = E^{n}_{J-1/2} + (S_R + S_Z)\Delta t^{n+1/2} + \left[.5\left[P^{n+1}_{J-1/2} + P^{n}_{J-1/2}\right] + Q^{n+1}_{J-1/2}\right]\left(V^{n}_{J-1/2} - V^{n+1}_{J-1/2}\right)$
$\left|\frac{**E - *E}{**E}\right| : x6$
<
100
$E^{n+1}_{J-1/2} = *E$
≥
20
*E = **E
PET
NCOT = NCOT + 1
NCOT :10
≤
>
PRINT MESSAGE
EXIT
j : J_IR
≠
=
IR = IR + 1
S_R FROM REGSR
170
IANS FROM JHT
160
j : j_MAX
≥
180
RET
<
≥
J : Ĵ
IANS :0
≠
=
RET
ĵ = ĵ + 1
<
165
j = j + 1

11. REGSR(NR,SR)

REGSR determines the source or sink term, SR, for region NR. It does this by adding the proper value of the step function for that region to SFN, the source or sink term returned by RGSRFN, the subroutine for calculating non-step source or sink functions.

```
$IBFTC REGSR    REF
      SUBROUTINE REGSR (NR,SR)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED H
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
       INTEGER RS
      IR=1
      SR=0.
   90 IF (NR.EQ.RS(IR) ) GO TO 100
      IF (IR.GE.NRSRCE) GO TO 120
      IR=IR+1
      GO TO 90
  100 IF (NRS(IR).EQ.1) GO TO 130
      K=1
  110 IF (TM.LE.TMRS(K,IR) ) GO TO 140
      IF (K.GE.NRS(IR) ) GO TO 120
      K=K+1
      GO TO 110
  120  CALL RGSRFN(NR,SFN)
       SR=SR+SFN
       RETURN
  130  IF(TM.GT.TMRS(1,IR)) GO TO 120
      SR=ERS(1,IR)
      GO TO 120
  140 SR=ERS(K,IR)
      GO TO 120
      END
```

REGSR


START
IR = 1
$S_R = 0$
90
NR: RS(IR)
=
≠
IR: NRSRCE
≥
<
IR = IR + 1
100
NRS_{IR}: 1
=
≠
K = 1
130
t: $TMRS_{1,IR}$
≤
>
$S_R = ERS_{1,IR}$
110
t: $TMRS_{K,IR}$
≤
>
140
$S_R = ERS_{K,IR}$
≥
K: NRS_{IR}
<
K = K + 1
120
SFN FROM RGSRFN
$S_R = S_R + SFN$
RET

12. RGSRFN(NR,SFN)

The analytic source function for a region is defined in this subroutine and its value is returned as SFN. As this subroutine is always called by REGSR a dummy entry point is provided in ALIBI and also SFN is set to zero.

13. ZONSR(J,SZ)

ZONSR is similar to REGSR, but controls zone sinks and sources.

```
$IBFTC ZONSR   REF
      SUBROUTINE ZONSR (J,SZ)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED H
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
      IZ=1
      SZ=C.
  10C IF (J.EQ.JS(IZ) ) GO TO 120
      IF (IZ.GE.NZSRCE)  GO TO 160
      IZ=IZ+1
      GO TO 100
  12C IF (NZS(IZ).EQ.1)  GO TO 150
      K=1
  130 IF (TM.LE.TMS(K,IZ) ) GO TO 140
      IF (K.GE.NZS(IZ) ) GO TO 160
      K=K+1
      GO TO 130
  14C SZ=ES(K,IZ)
      GC TC 160
  15C  IF(TM.GT.TMS(1,IZ)) GO TO 160
      SZ=ES(1,IZ)
  16C  CALL ZNSRFN(J,SFN)
       SZ=SZ+SFN
       RETURN
       END
```

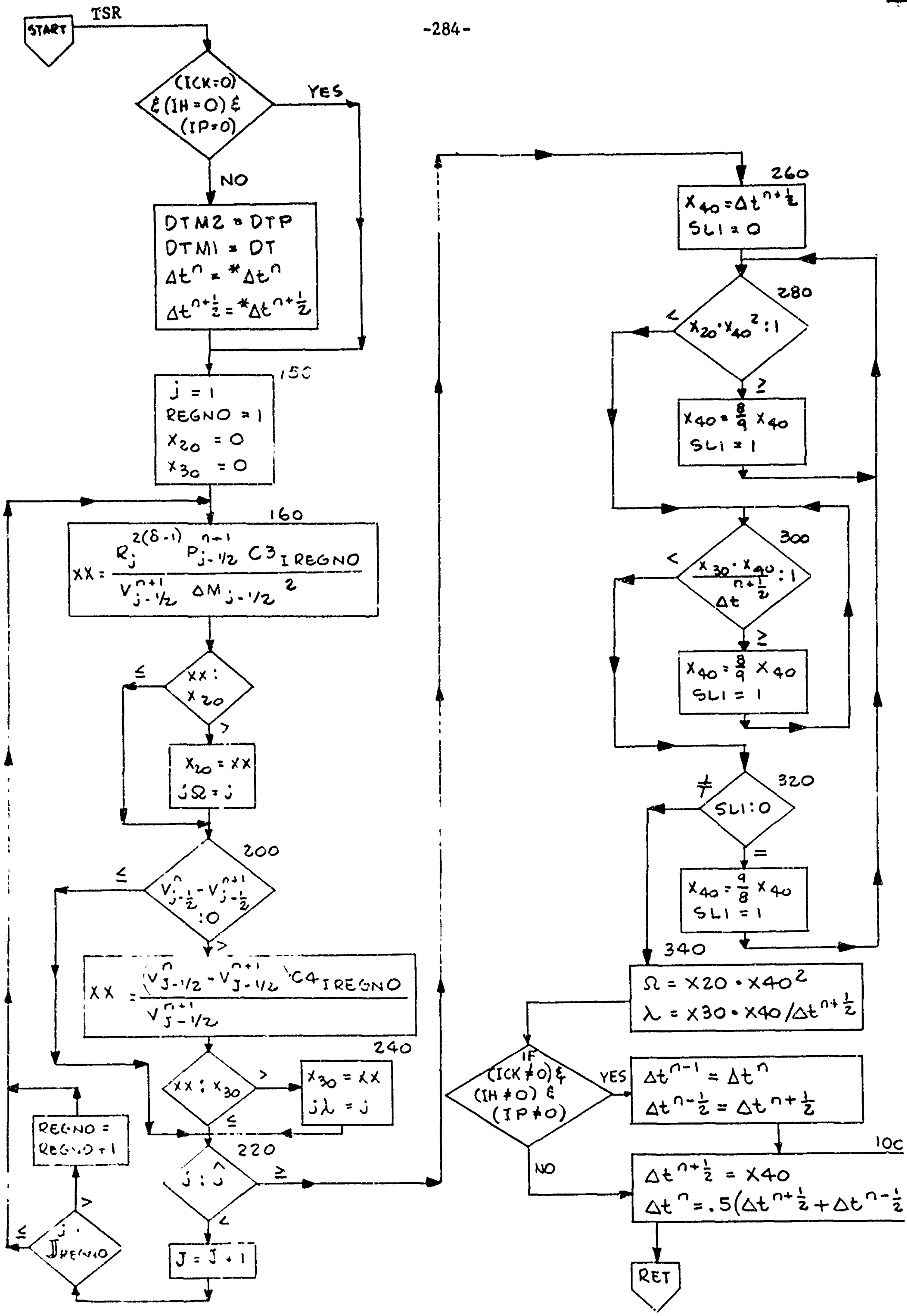
14. ZNSRFN(J,SRN)

ZNSRFN is similar to RGSRFN, but controls zone non-step sink and sources.

15. TSR(C)

TSR is the time stability routine for hydrodynamics only problems. It is called by EXEC and controls the size of Δt. ICK, IH, IP are flags coming from PPR. If they are not equal to zero this indicates that the Δt has been modified in PPR so that the next cycle will have the exact time of print out, history edit and energy edit specified. In order to continue the problem with the maximum possible time-step, as determined by stability criteria in TSR, the original time-step is preserved as in PPR as DTPS and DTS.

```
$IBFTC TSR     REF
      SUBROUTINE TSR(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KOM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
       IF(ICK.EQ.0.AND.IH.EQ.0.AND.IP.EQ.0) GO TO 150
      DTM2 = DTP
      DTM1 = DT
      DTP =DTPS
      DT = DTS
  150 J=1
      REGNO=1
      X20=0.
      X30=0.
  160 XX=R(J+1)**(2*(DELTA-1))*PR(J+1)*C3(REGNO)/(VL(J+1)*DMASS(J+1)**2)
      IF (XX.LE.X20) GO TO 200
      X20=XX
       JOMEGA=J
  200 IF (VLM(J+1)-VL(J+1).LE.0.) GO TO 220
      XX=(VLM(J+1)-VL(J+1))*C4(REGNO)/VL(J+1)
      IF (XX.GT.X30) GO TO 240
  220 IF (J.GE.JHAT) GO TO 260
      J=J+1
      IF (J.LE.JREG(REGNO) ) GO TO 160
      REGNO=REGNO+1
      GO TO 160
  240 X30=XX
       JLAM=J
      GO TO 220
  260 X40=DTP
      SL1=0.
  280 IF (X20*X40**2.LT.1.) GO TO 300
      X40= 8.*X40/9.
      SL1=1.
      GO TO 280
  300 IF (X30*X40/DTP.LT.1.) GO TO 320
      X40=8.*X40/9.
      SL1=1.
      GO TO 300
  320 IF (SL1.NE.0.) GO TO 340
      X40=9.*X40/8.
      SL1=1.
      GO TO 280
  340 OMEGA=X20*X40**2
      AMBDA=X30*X40/DTP
      IF (ICK.NE.0.AND.IH.NE.0.AND.IP.NE.0) GO TO 1000
      DTM1=DT
      DTM2=DTP
 1000 DTP = X40
      DT= .5*(DTP+DTM2)
      RETURN
      END
```

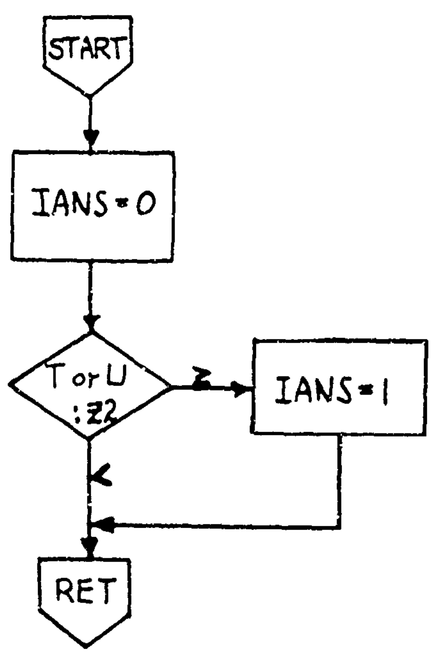

START
TSR
(ICK=0) & (IH=0) & (IP=0)
YES
NO
DTM2 = DTP
DTM1 = DT
$\Delta t^n = {}^*\Delta t^n$
$\Delta t^{n+\frac{1}{2}} = {}^*\Delta t^{n+\frac{1}{2}}$
150
j = 1
REGNO = 1
$X_{20} = 0$
$X_{30} = 0$
160
$XX = \frac{R_j^{2(\delta-1)} P_{j-1/2}^{n-1} C3_{IREGNO}}{V_{j-1/2}^{n+1} \Delta M_{j-1/2}^2}$
XX : X_{20}
≤
>
X_{20} = XX
jΩ = j
200
$V_{j-\frac{1}{2}}^{n} - V_{j-\frac{1}{2}}^{n+1}$: 0
≤
>
$XX = \frac{(V_{J-1/2}^{n} - V_{J-1/2}^{n+1}) C4_{IREGNO}}{V_{J-1/2}^{n+1}}$
240
XX : X_{30}
>
≤
X_{30} = XX
jλ = j
220
j : Ĵ
≥
<
J = J + 1
j : J_{REGNO}
≤
>
REGNO = REGNO + 1
260
$X_{40} = \Delta t^{n+\frac{1}{2}}$
SL1 = 0
280
$X_{20} \cdot X_{40}^2 : 1$
<
≥
$X_{40} = \frac{8}{9} X_{40}$
SL1 = 1
300
$\frac{X_{30} \cdot X_{40}}{\Delta t^{n+\frac{1}{2}}} : 1$
<
≥
$X_{40} = \frac{8}{9} X_{40}$
SL1 = 1
320
SL1 : 0
≠
=
$X_{40} = \frac{9}{8} X_{40}$
SL1 = 1
340
$\Omega = X20 \cdot X40^2$
$\lambda = X30 \cdot X40/\Delta t^{n+\frac{1}{2}}$
IF (ICK≠0) & (IH≠0) & (IP≠0)
YES
NO
$\Delta t^{n-1} = \Delta t^n$
$\Delta t^{n-\frac{1}{2}} = \Delta t^{n+\frac{1}{2}}$
100
$\Delta t^{n+\frac{1}{2}} = X40$
$\Delta t^n = .5(\Delta t^{n+\frac{1}{2}} + \Delta t^{n-\frac{1}{2}})$
RET

16. JHT(T,U,Z2,IANS)

JHT is called by ROA, ROAEXP or ROAIMP, to check the value of TEM(JHAT) (or K(JHAT)) versus Z2. If this value exceeds the criterion, IANS is set to one and JHAT is increased by one in the calling subroutine. If temperature (or velocity) of the zone is greater than or equal to Z2, it sets IANS=1 and returns. The calling routine then modifies JHAT accordingly.

```
$IBFTC JHTT    REF
      SUBROUTINE JHT(T,U,Z2,IANS)
      IANS=0
      IF(T.GE.Z2) IANS=1
      RETURN
      END
```

```
$IBFTC JHTU    REF
      SUBROUTINE JHT(T,U,Z2,IANS)
      IANS=0
      IF(U.GE.Z2) IANS=1
      RETURN
      END
```



17. ROAEXP(C)

ROAEXP is called by EXEC. It does the non-hydrodynamics calculations for explicit radiation problems.

The P, E and T convergence schemes are essentially the same as those for ROA for hydro only. In addition, ROAEXP calculates K, K∆M and L.

```
$IBFTC ROAEXP  REF
       SUBROUTINE ROAEXP(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HE
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HE
      DIMENSION C(1)
       J=1
       IR=1
    1  EX=0.
       P12=PRM(J+1)
       NCOT=0
   10  EG(J+1)=EGM(J+1)+(P12+Q(J+1))*(VLM(J+1)-VL(J+1)) +
     1         DTP*(ELM(J)-ELM(J+1))/DMASS(J+1) - D(J+1)
       CALL GETVAR(2,2,EG(J+1),VL(J+1),J,TEM(J+1),C)
      TEM4(J+1)=TEM(J+1)**4
       CALL PEK(1,MAT(J+1),TEM(J+1),VL(J+1),J,0,PR(J+1),C)
       IF(NCOT.GT.10) GO TO 20
       IF(ABS((EX-EG(J+1))/EG(J+1)).LE.X6) GO TO 50
       P12=(PR(J+1)+PRM(J+1))/2.
       EX=EG(J+1)
      NCOT=NCOT+1
       GO TO 10
   20 PRINT 1000, EX,EG(J+1),TEM(J+1),J,PR(J+1)
 1000 FORMAT(11HCRDAR ERROR  3E16.7,I6,E16.7)
       CALL EXIT
   50  IF(J.GT.JSTAR+1) GO TO 100
       TAM(J)=((TEM4(J+1)+TEM4(J))/2.)**.25
       IF(J.NE.1) GO TO 90
      IF (NKMIN.EQ.0) KM(J) = 0.
       GO TO 95
   90  CALL PEK(3,MAT(J),TAM(J),VL(J),J-1,0,KM(J),C)
   95  CALL PEK(3,MAT(J+1),TAM(J),VL(J+1),J-1,0,KP(J),C)
       KDM(J)=.5*DMASS(J)*KM(J) + .5*DMASS(J+1)*KP(J)
       IF(R(J).LE.0.) GO TO 100
       EL(J)= R(J)**(2*(DELTA-1))*(TEM4(J)-TEM4(J+1))/KDM(J)
  100  IF (J.GE.JMAX) RETURN
       IF (J.GT.JSTAR+1) GO TO 120
  115  J=J+1
       GO TO 1
  120  IF(J.LE.JHAT+1) GO TO 115
```

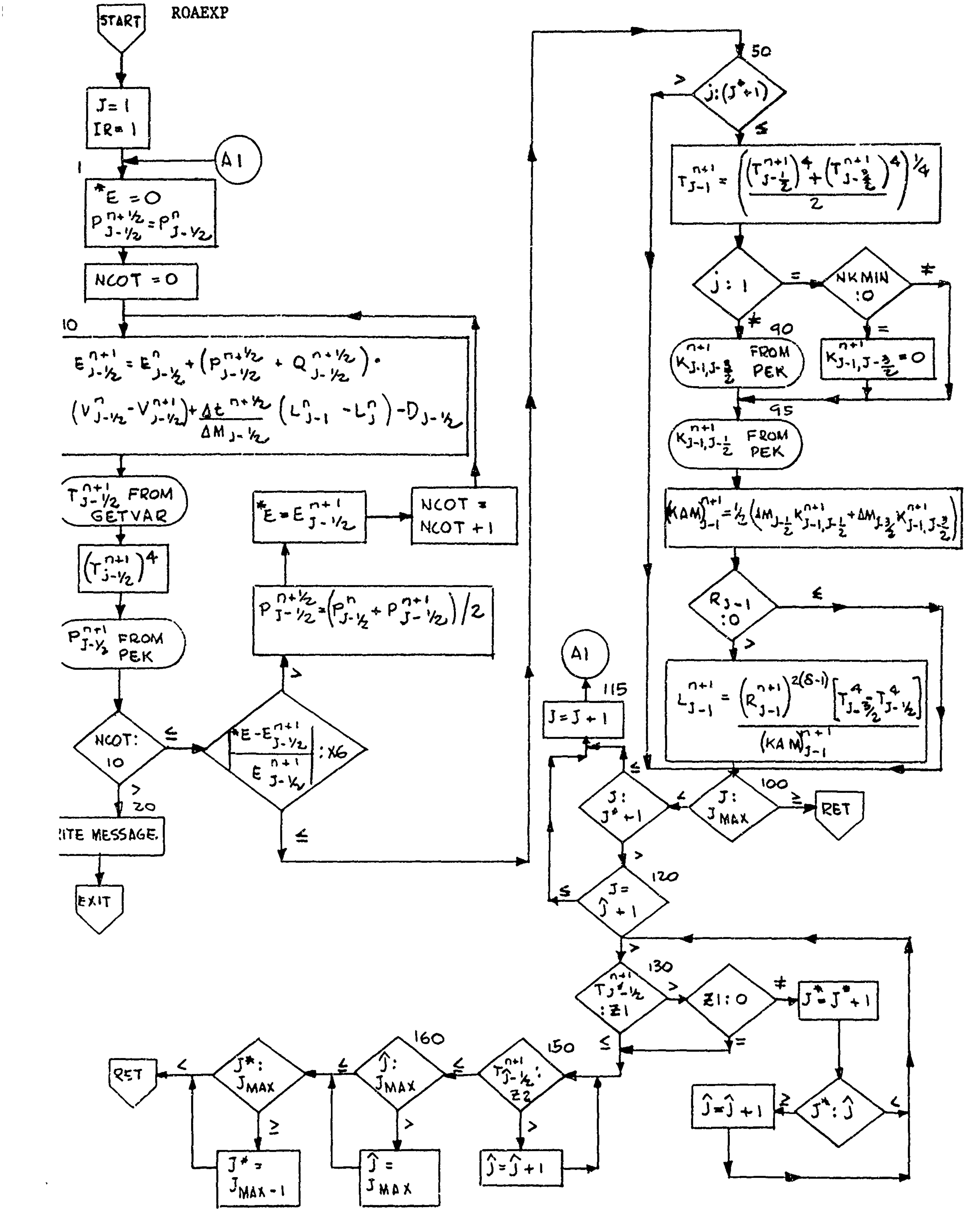
```
130   IF(TEM(JSTAR+1).LE.Z1) GO TO 150
      IF(Z1.EQ.0.) GO TO 150
      JSTAR=JSTAR+1
      IF(JSTAR.LT.JHAT) GO TO 130
      JHAT=JHAT+1
      GO TO 130
150   IF(TEM(JHAT+1).LE.Z2)GO TO 160
      JHAT=JHAT+1
      GO TO 150
160   IF(JHAT.GT.JMAX) JHAT=JMAX
      IF(JSTAR.GE.JMAX) JSTAR=JMAX-1
      RETURN
      END
```

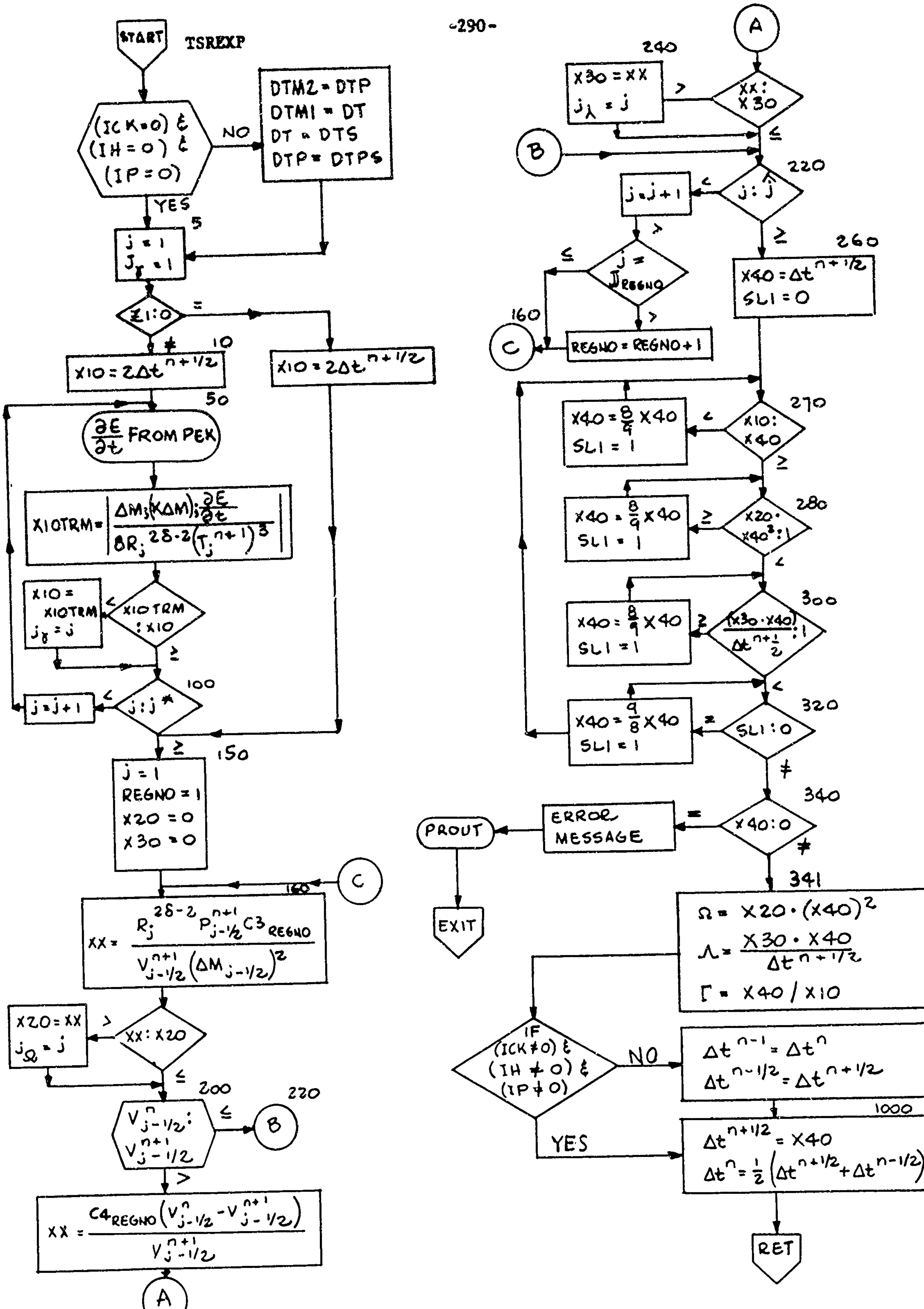
18. TSREXP(C)

TSREXP is called by EXEC. It controls the size of Δt in explicit radiation problems.

```
$IBFTC TSREXP  REF
       SUBROUTINE TSREXP(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
       IF(ICK.EQ.0.AND.IH.EQ.0.AND.IP.EQ.0) GO TO 5
      DTM2 = DTP
      DTM1 = DT
      DTP =DTPS
      DT = DTS
    5 J=1
       JGAMMA=1
       IF(Z1.NE.0.) GO TO 10
       X10=DTP*2.
       GO TO 150
   10  X10=DTP*2.
   50  CALL PEK(2,MAT(J+1),TAM(J+1),VL(J+1),J,1,DE,C)
       X10TRM=DMESS(J+1)*KDM(J+1)*DE/(8.*R(J+1)**(2*(DELTA-1))
     1   *TAM(J+1)**3)
       X10TRM=ABS(X10TRM)
       IF(X10TRM.GE.X10) GO TO 100
       JGAMMA=J
       X10=X10TRM
  100 IF(J.GE.JSTAR) GO TO 150
      J=J+1
      GO TO 50
  150 J=1
      REGNO=1
      X20=0.
      X30=0.
```

```
160 XX=R(J+1)**(2*(DELTA-1))*PR(J+1)*C3(REGNO)/(VL(J+1)*DMASS(J+1)**2
    IF (XX.LE.X20) GO TO 200
    X20=XX
     JOMEGA=J
200 IF (VLM(J+1)-VL(J+1).LE.0.) GO TO 220
    XX=(VLM(J+1)-VL(J+1))*C4(REGNO)/VL(J+1)
    IF (XX.GT.X30) GO TO 240
220  IF(J.GE.JHAT  ) GO TO 260
    J=J+1
    IF (J.LE.JREG(REGNO) ) GO TO 160
    REGNO=REGNO+1
    GO TO 160
240 X30=XX
     JLAM=J
    GO TO 220
260 X40=DTP
    SL1=0.
270  IF(X10.GE.X40) GO TO 280
     X40=8.*X40/9.
    SL1=1.
     GO TO 270
280 IF (X20*X40**2.LT.1.) GO TO 300
    X40= 8.*X40/9.
    SL1=1.
    GO TO 280
300 IF (X30*X40/DTP.LT.1.) GO TO 320
    X40=8.*X40/9.
    SL1=1.
    GO TO 300
320 IF (SL1.NE.0.) GO TO 340
    X40=9.*X40/8.
    SL1=1.
     GO TO 270
340  IF(X40.NE.0.) GO TO 341
     PRINT 7000, X10,X20,X30,JGAMMA,JOMEGA,JLAM
7000 FORMAT(3E16.7 ,3I6)
    CALL PROUT(C)
     CALL EXIT
341 OMEGA=X20*X40**2
    AMBDA=X30*X40/DTP
     GAMMA=X40/X10
    IF (ICK.NE.0.AND.IH.NE.0.AND.IP.NE.0) GO TO 1000
    DTM1=DT
    DTM2=DTP
1000 DTP = X40
    DT= .5*(DTP+DTM2)
    RETURN
     END
```


ROAEXP
START
J = 1
IR = 1
A1
*E = 0
NCOT = 0
FROM GETVAR
FROM PEK
NCOT : 10
WRITE MESSAGE
EXIT
*E = E
NCOT = NCOT + 1
: X6
j : (J* + 1)
j : 1
NKMIN : 0
FROM PEK
FROM PEK
J = J + 1
A1
J : J* + 1
J : JMAX
RET
J = Ĵ + 1
Z1 : 0
J* = J* + 1
J* : Ĵ
Ĵ = Ĵ + 1
: Z1
: Z2
Ĵ : JMAX
J* : JMAX
RET
Ĵ = Ĵ + 1
Ĵ = JMAX
J* = JMAX - 1

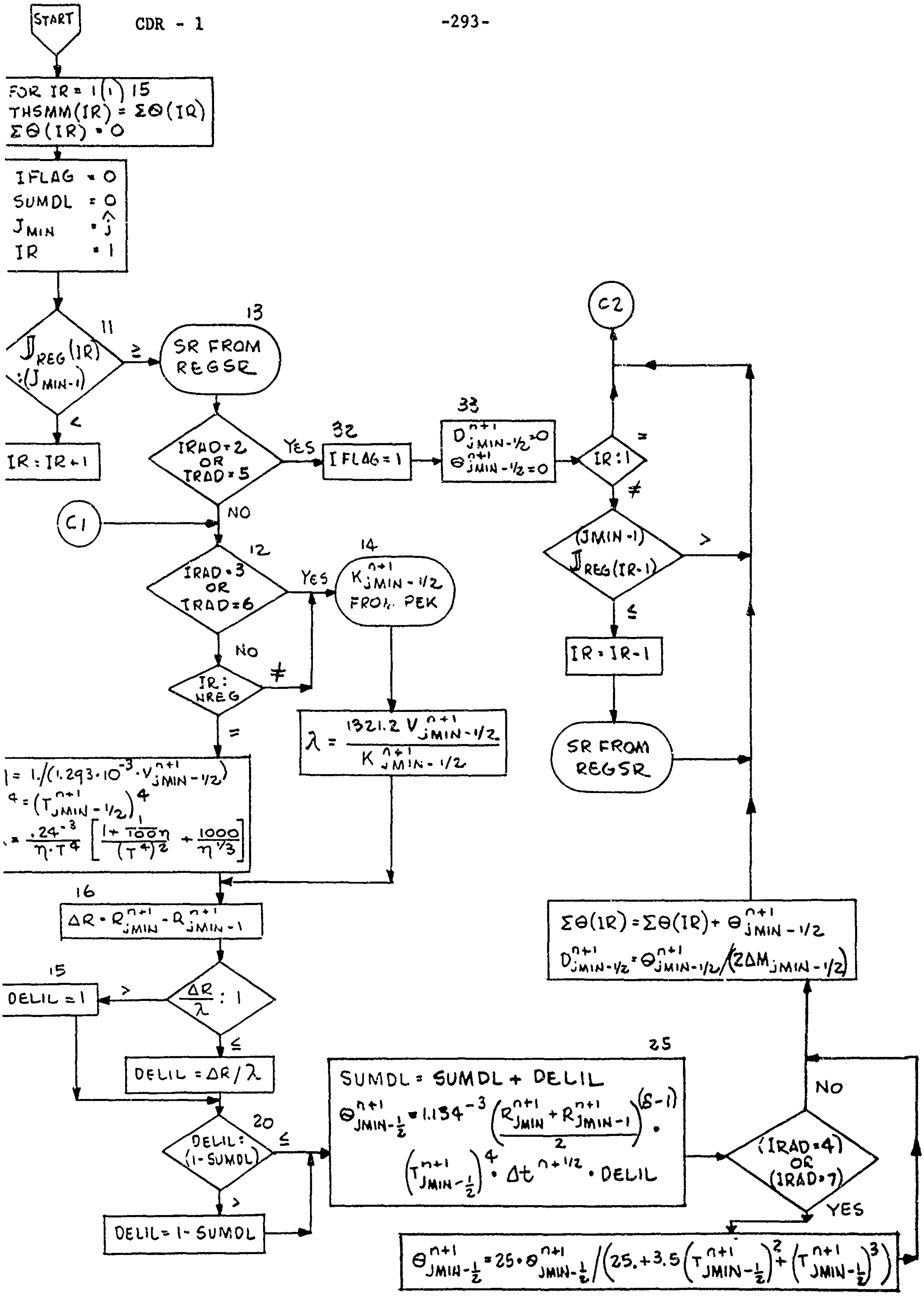

START
TSREXP
(ICK=0) & (IH=0) & (IP=0)
NO
YES
DTM2 = DTP
DTM1 = DT
DT = DTS
DTP = DTPS
5
j = 1
j_γ = 1
Z1:0
10
X10 = 2Δt^(n+1/2)
X10 = 2Δt^(n+1/2)
50
∂E/∂t FROM PEK
XIOTRM = |ΔM_j(KΔM)_j ∂E/∂t / 8R_j^(2δ-2)(T_j^(n+1))^3|
X10 = XIOTRM
j_γ = j
XIOTRM : X10
100
j = j+1
j : j*
150
j = 1
REGNO = 1
X20 = 0
X30 = 0
C
160
XX = R_j^(2δ-2) P_(j-1/2)^(n+1) C3_REGNO / V_(j-1/2)^(n+1) (ΔM_(j-1/2))^2
X20 = XX
j_Ω = j
XX : X20
200
220
V_(j-1/2)^n : V_(j-1/2)^(n+1)
B
XX = C4_REGNO (V_(j-1/2)^n - V_(j-1/2)^(n+1)) / V_(j-1/2)^(n+1)
A
A
240
X30 = XX
j_λ = j
XX : X30
B
220
j = j+1
j : ĵ
j = ĵ_REGNO
160
C
REGNO = REGNO+1
260
X40 = Δt^(n+1/2)
SL1 = 0
270
X40 = 8/9 X40
SL1 = 1
X10 : X40
280
X40 = 8/9 X40
SL1 = 1
X20 · X40^2 : 1
300
X40 = 8/9 X40
SL1 = 1
(X30 · X40) / Δt^(n+1/2) : 1
320
X40 = 9/8 X40
SL1 = 1
SL1 : 0
340
PROUT
ERROR MESSAGE
X40 : 0
EXIT
341
Ω = X20 · (X40)^2
Λ = X30 · X40 / Δt^(n+1/2)
Γ = X40 / X10
IF (ICK≠0) & (IH≠0) & (IP≠0)
NO
YES
Δt^(n-1) = Δt^n
Δt^(n-1/2) = Δt^(n+1/2)
1000
Δt^(n+1/2) = X40
Δt^n = 1/2 (Δt^(n+1/2) + Δt^(n-1/2))
RET

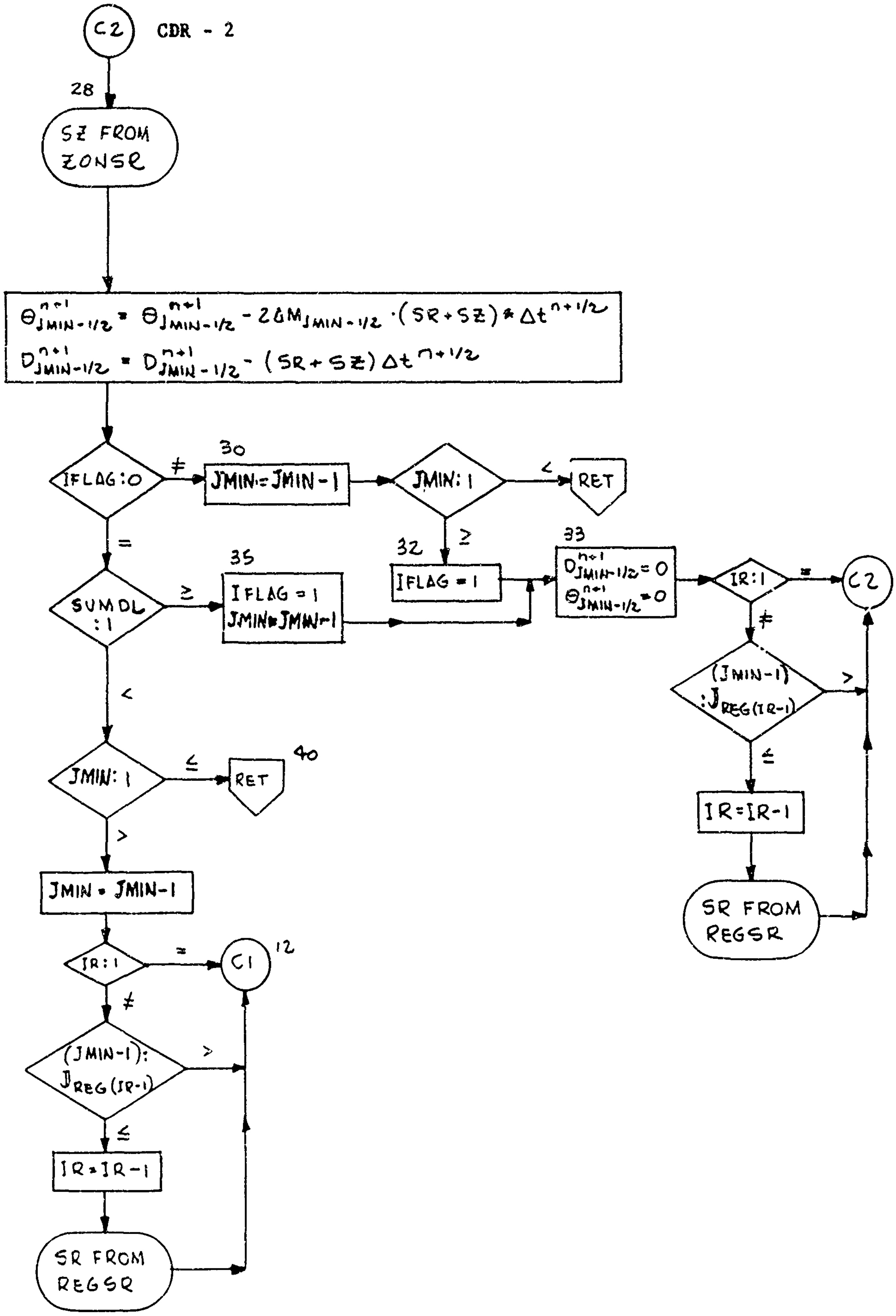
19. CDR(C)

CDR is called by EXEC. It computes the radiation depletion term.

```
$IBFTC CDR     REF
       SUBROUTINE CDR(C)
C      COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C      SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
       DIMENSION C(1)
       DO 5  IR=1,15
  5    THSMM(IR)= THSUM(IR)
       DO 10  IR=1,15
  10   THSUM(IR)=0.
       IFLAG=0
       SUMDL=0.
       JMIN=JHAT
       IR=1
   11  IF(JREG(IR).GE.JMIN-1) GO TO 13
       IR=IR+1
       GO TO 11
   13  CALL REGSR(IR,SR)
      IF (IRAD.EQ.2.OR.IRAD.EQ.5) GO TO 32
   12 IF (IRAD.EQ.3.OR.IRAD.EQ.6) GO TO 14
      IF (IR.NE.NREG) GO TO 14
      ETA = 1./(1.293E-3*VL(JMIN))
      T4 = TEM(JMIN)**4
      FLAM = .24E-3*((1.+1./(100.*ETA))/T4**2 + 1000./ETA**.33333333)/
     1  (ETA*T4)
      GO TO 16
   14  CALL PEK(3,MAT(JMIN),TEM(JMIN),VL(JMIN),JMIN-1,0,FK,C)
       FLAM=1.3212E+3*VL(JMIN)/FK
   16  DELER=R(JMIN)-R(JMIN-1)
       IF(DELER/FLAM.GT.1.) GO TO 15
       DELIL=DELER/FLAM
       GO TO 20
   15  DELIL=1.
   20  IF(DELIL.LE.1.-SUMDL) GO TO 25
       DELIL=1.-SUMDL
   25  SUMDL=SUMDL+DELIL
      THETA(JMIN)=1.134E-3*((R(JMIN)+R(JMIN-1))/2.)**(DELTA-1)*TEM4(JMIN
     1  )*DTP*DELIL
      IF (IRAD.EQ.7) THETA(JMIN)=THETA(JMIN)*25./(25.+3.5*TEMSQ(JMIN)+
     1    TEM3(JMIN))
      IF (IRAD.EQ.4) THETA(JMIN)=THETA(JMIN)*25./(25.+3.5*TEMSQ(JMIN)+
     1    TEM3(JMIN))
```

```
      THSUM(IR)=THSUM(IR)+THETA(JMIN)
      D(JMIN)=THETA(JMIN)/(2.*DMASS(JMIN))
   28 CALL ZONSR(JMIN-1,SZ)
      THETA(JMIN)=THETA(JMIN)-2.*DMASS(JMIN)*(SR+SZ)*DTP
      D(JMIN)=D(JMIN)-(SR+SZ)*DTP
      IF(IFLAG.NE.0) GO TO 30
      IF(SUMDL.GE.1.) GO TO 35
      IF(JMIN.LE.1) GO TO 40
      JMIN=JMIN-1
      IF(IR.EQ.1) GO TO 12
      IF(JMIN-1.GT.JREG(IR-1)) GO TO 12
      IR=IR-1
      CALL REGSR(IR,SR)
      GO TO 12
   30 JMIN=JMIN-1
      IF(JMIN.LT.1) RETURN
   32 IFLAG=1
   33 D(JMIN)=0.
      THETA(JMIN)=0.
      IF(IR.EQ.1) GO TO 28
      IF(JMIN-1.GT.JREG(IR-1)) GO TO 28
      IR=IR-1
      CALL REGSR(IR,SR)
      GO TO 28
   35 IFLAG=1
      JMIN=JMIN-1
      GO TO 33
   40 RETURN
      END
```


START
FOR IR = 1(1) 15
THSMM(IR) = ΣΘ(IR)
ΣΘ(IR) = 0
IFLAG = 0
SUMDL = 0
JMIN = ĵ
IR = 1
11
JREG(IR) :(JMIN-1)
≥
<
IR : IR+1
13
SR FROM REGSR
IRAD=2 OR IRAD=5
YES
32
IFLAG=1
33
D n+1 JMIN-1/2 = 0
Θ n+1 JMIN-1/2 = 0
IR:1
=
≠
(JMIN-1) JREG(IR-1)
>
≤
IR = IR-1
SR FROM REGSR
C2
NO
C1
12
IRAD=3 OR IRAD=6
YES
14
K n+1 JMIN-1/2 FROM PEK
NO
IR: NREG
≠
=
λ = 1321.2 V n+1 JMIN-1/2 / K n+1 JMIN-1/2
16
ΔR = R n+1 JMIN - R n+1 JMIN-1
15
DELIL = 1
>
ΔR/λ : 1
≤
DELIL = ΔR/λ
20
DELIL:(1-SUMDL)
≤
>
DELIL= 1- SUMDL
25
SUMDL = SUMDL + DELIL
ΣΘ(IR) = ΣΘ(IR) + Θ n+1 JMIN-1/2
D n+1 JMIN-1/2 = Θ n+1 JMIN-1/2 / (2ΔM JMIN-1/2)
(IRAD=4) OR (IRAD=7)
NO
YES

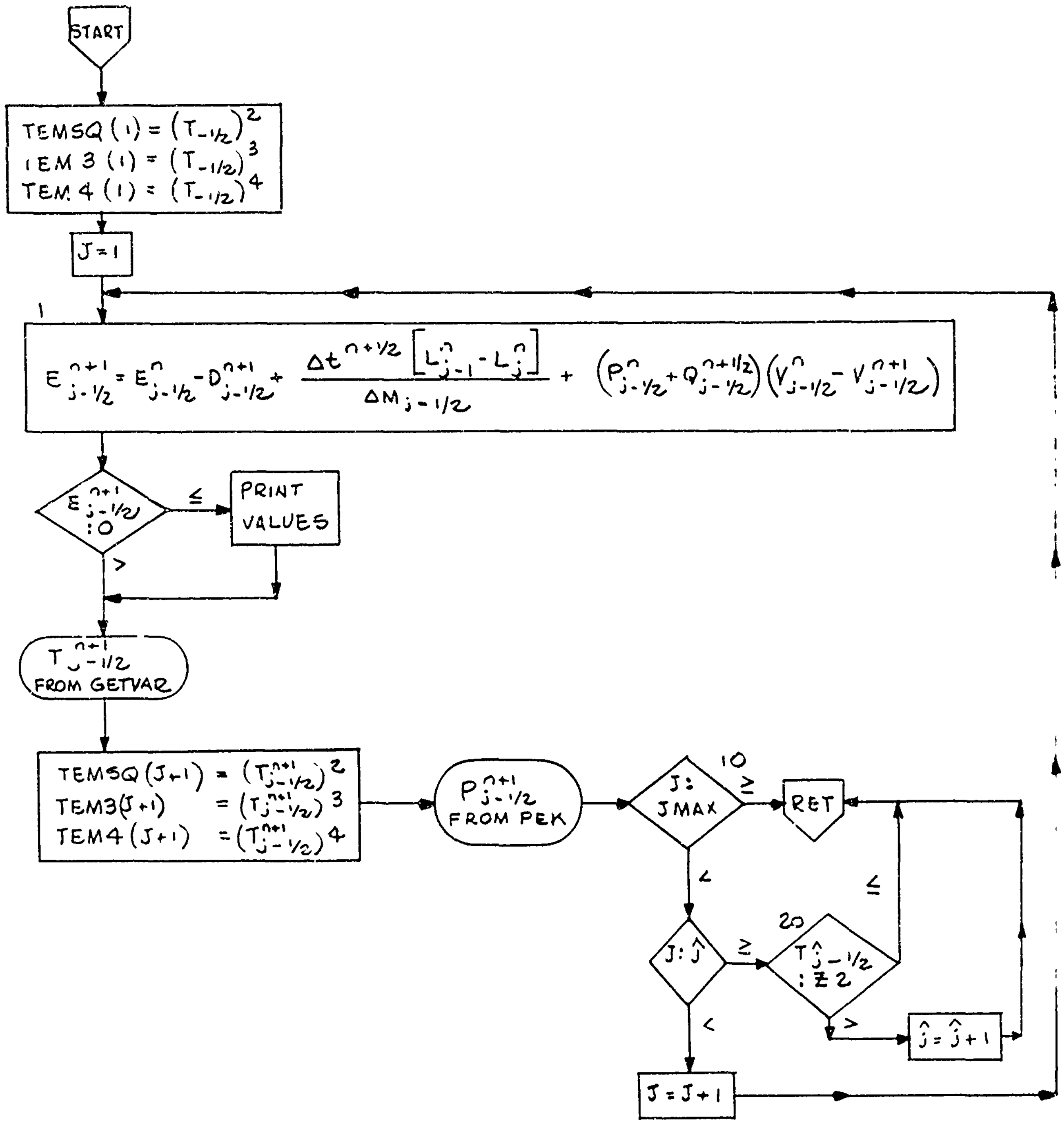

C2
CDR - 2
28
SZ FROM ZONSR
$\Theta^{n+1}_{JMIN-1/2} = \Theta^{n+1}_{JMIN-1/2} - 2\Delta M_{JMIN-1/2} \cdot (SR+SZ) * \Delta t^{n+1/2}$
$D^{n+1}_{JMIN-1/2} = D^{n+1}_{JMIN-1/2} - (SR+SZ)\Delta t^{n+1/2}$
IFLAG:0
≠
30
JMIN=JMIN-1
JMIN:1
<
RET
≥
=
32
IFLAG=1
33
$D^{n+1}_{JMIN-1/2}=0$
$\Theta^{n+1}_{JMIN-1/2}=0$
IR:1
=
C2
35
SUMDL:1
≥
IFLAG=1
JMIN=JMIN-1
≠
(JMIN-1):$J_{REG(IR-1)}$
>
≤
IR=IR-1
SR FROM REGSR
<
JMIN:1
≤
RET
40
>
JMIN=JMIN-1
IR:1
=
C1
12
≠
(JMIN-1):$J_{REG(IR-1)}$
>
≤
IR=IR-1
SR FROM REGSR

20. ROAIMP(C)

ROAIMP is called by EXEC. It computes the first guess for energy, temperature and pressure for implicit radiation.

```
$IBFTC ROAIMP  REF
      SUBROUTINE ROAIMP(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
      INTEGER  DELTA, REGNO, UNCGS, UNMKS
      REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
      TEMSQ(1)=TEM(1)**2
      TEM3(1)=TEMSQ(1)*TEM(1)
      TEM4(1)=TEMSQ(1)**2
      J=1
    1 EG(J+1)=EGM(J+1)                 - D(J+1) + DTP*(ELM(J)-ELM(J+1))/
     1   DMASS(J+1) + (PRM(J+1)+Q(J+1))*(VLM(J+1)-VL(J+1))
      IF(EG(J+1).LE.0.) PRINT 1000,J,EG(J+1),EGM(J+1),D(J+1),DTP,ELM(J),
     1ELM(J+1),DMASS(J+1),PRM(J+1),Q(J+1),VLM(J+1),VL(J+1)
 1000 FORMAT (93H0J,EG(J+1),EGM(J+1),D(J+1),DTP,ELM(J),ELM(J+1),DMASS(J+
     11),PRM(J+1),Q(J+1),VLM(J+1),VL(J+1)   //I10,5E20.7//6E20.7)
      CALL GETVAR(2,2,EG(J+1),VL(J+1),J,TEM(J+1),C)
      TEMSQ(J+1)=TEM(J+1)*TEM(J+1)
      TEM3(J+1)=TEM(J+1)*TEMSQ(J+1)
      TEM4(J+1)=TEMSQ(J+1)*TEMSQ(J+1)
      CALL PEK(1,MAT(J+1),TEM(J+1),VL(J+1),J,0,PR(J+1),C)
   10 IF(J.GE.JMAX) RETURN
      IF(J.GE.JHAT) GO TO 20
      J=J+1
      GO TO 1
   20 IF(TEM(JHAT+1).LE.Z2) RETURN
      JHAT=JHAT+1
      RETURN
      END
```

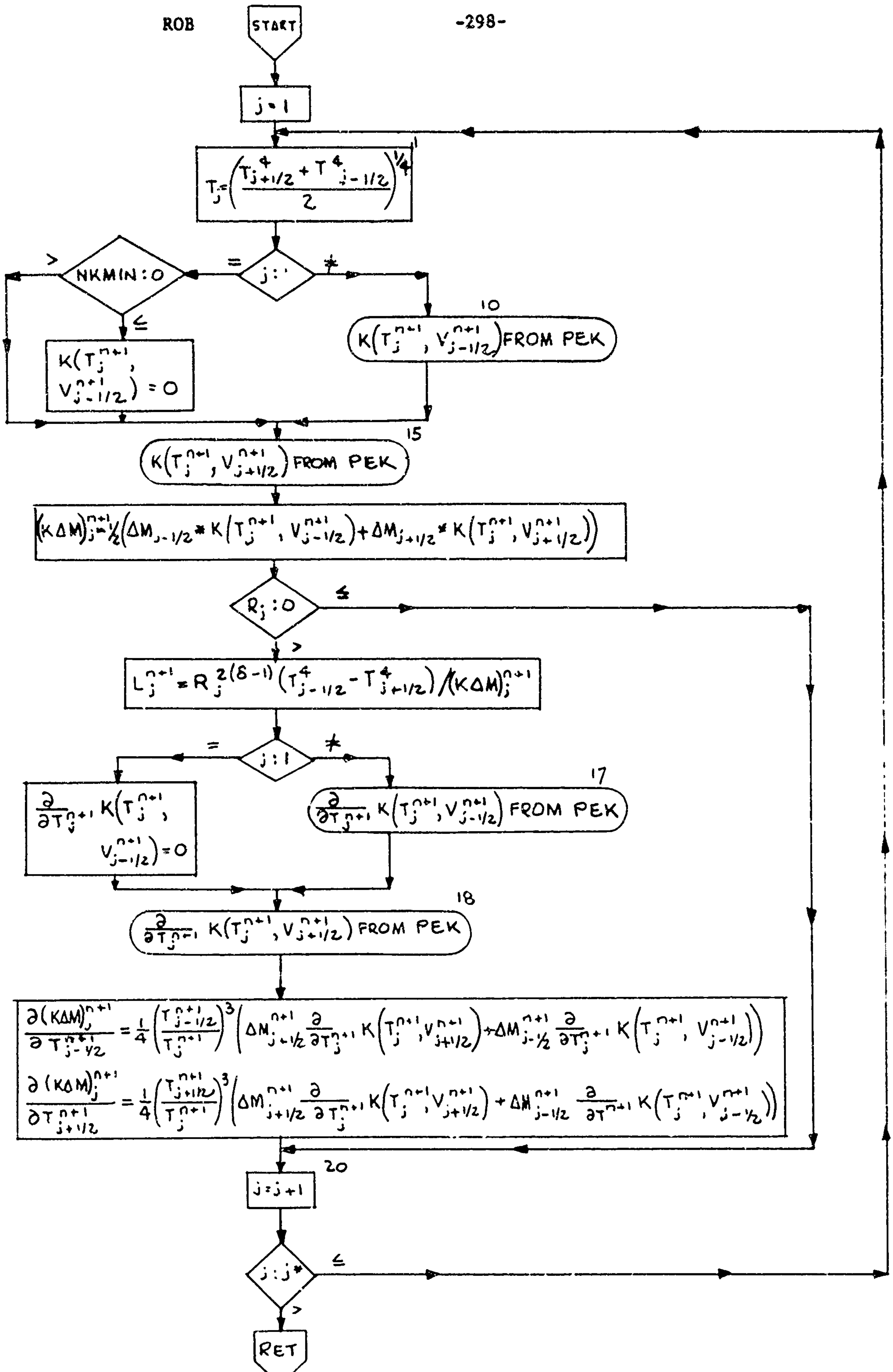
ROAIMP


START
TEMSQ (1) = $(T_{-1/2})^2$
TEM 3 (1) = $(T_{-1/2})^3$
TEM 4 (1) = $(T_{-1/2})^4$
J = 1
1
$E^{n+1}_{j-1/2} = E^n_{j-1/2} - D^{n+1}_{j-1/2} + \frac{\Delta t^{n+1/2}\left[L^n_{j-1} - L^n_j\right]}{\Delta M_{j-1/2}} + \left(P^n_{j-1/2} + Q^{n+1/2}_{j-1/2}\right)\left(V^n_{j-1/2} - V^{n+1}_{j-1/2}\right)$
$E^{n+1}_{j-1/2}$: 0
≤
PRINT VALUES
>
$T^{n+1}_{j-1/2}$ FROM GETVAR
TEMSQ (J+1) = $(T^{n+1}_{j-1/2})^2$
TEM3(J+1) = $(T^{n+1}_{j-1/2})^3$
TEM4 (J+1) = $(T^{n+1}_{j-1/2})^4$
$P^{n+1}_{j-1/2}$ FROM PEK
10
J : JMAX
≥
RET
<
≤
20
J : $\hat{j}$
≥
$T_{\hat{j}-1/2}$: Z 2
>
$\hat{j} = \hat{j} + 1$
<
J = J + 1

21. ROB(C)

ROB is called by EXEC. It computes the first guess for opacity and luminosity.

```
$IBFTC ROB     REF
       SUBROUTINE ROB(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA28/ GROUPS TO BE PLACED HERE
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
       DIMENSION C(1)
       J=1
    1  TAM(J)=((TEM4(J+1)+TEM4(J))/2.)**.25
       IF(J.NE.1) GO TO 10
       IF (NKMIN.GT.0) GO TO 15
       KM(1)=0.
       GO TO 15
   10  CALL PEK(3,MAT(J),TAM(J),VL(J),J-1,0,KM(J),C)
   15  CALL PEK(3,MAT(J+1),TAM(J),VL(J+1),J-1,0,KP(J),C)
       KDM(J)=(DMASS(J)*KM(J) + DMASS(J+1)*KP(J))*.5
       IF(R(J).LE.0.) GO TO 20
       CL(J)= R(J)**(2*(DELTA-1))*(TEM4(J)-TEM4(J+1))/KDM(J)
       IF(J.NE.1) GO TO 17
       DKMM=0.
       GO TO 18
   17  CALL PEK(3,MAT(J),TAM(J),VL(J),J-1,1,DKMM,C)
   18  CALL PEK(3,MAT(J+1),TAM(J),VL(J+1),J-1,1,DKMP,C)
       DKDMTM=DMASS(J+1)*DKMP+DMASS(J)*DKMM
       DKDMP(J)=.25*(TEM(J+1)/TAM(J))**3*DKDMTM
       DKDMM(J)=.25*(TEM(J)/TAM(J))**3*DKDMTM
   20  J=J+1
       IF(J.LE.JSTAR+1) GO TO 1
       RETURN
       END
```



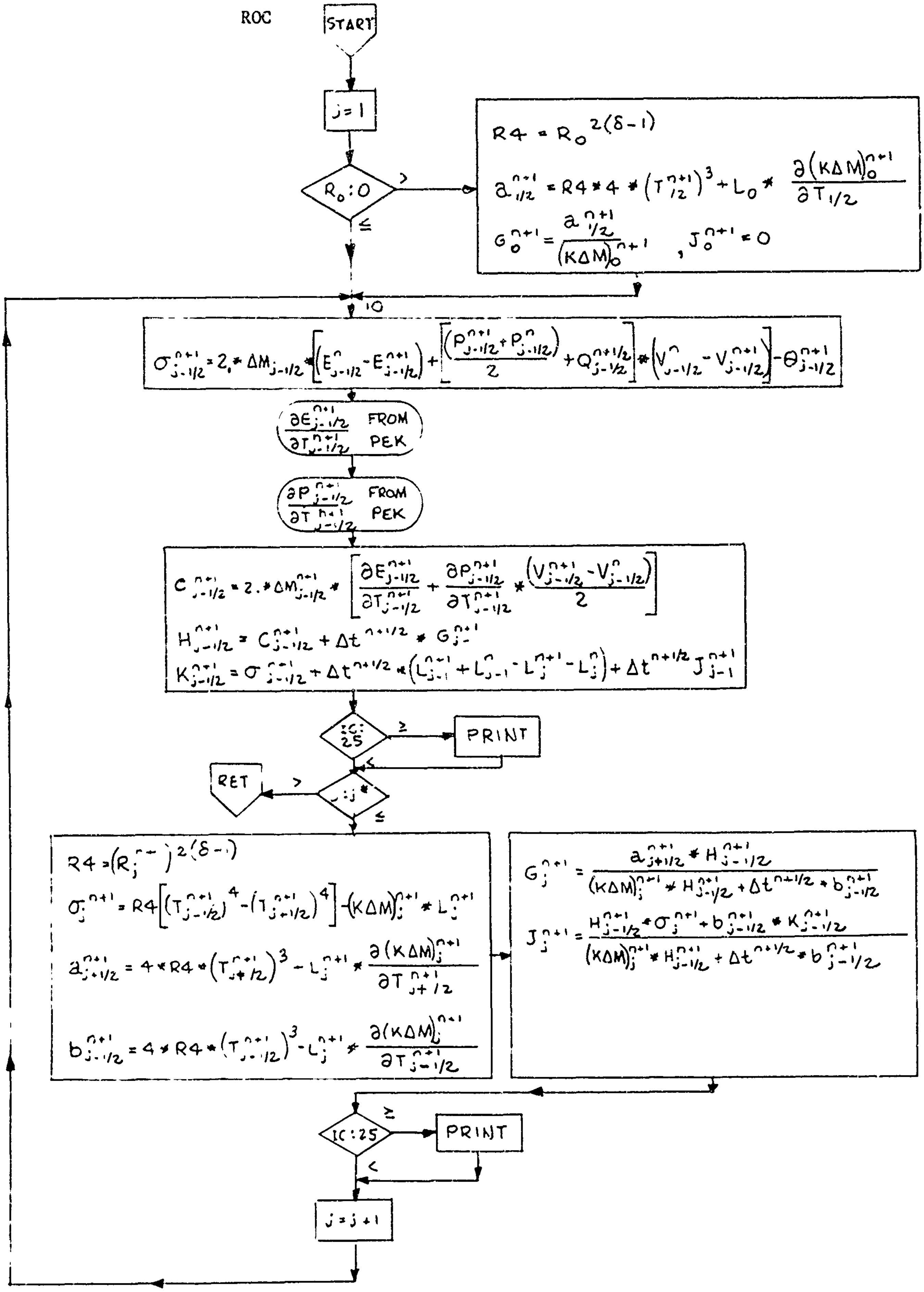
START
j = 1
1
$T_j = \left(\frac{T^4_{j+1/2} + T^4_{j-1/2}}{2}\right)^{1/4}$
NKMIN : 0
j : 1
10
$K(T_j^{n+1}, V_{j-1/2}^{n+1})$ FROM PEK
$K(T_j^{n+1}, V_{j-1/2}^{n+1}) = 0$
15
$K(T_j^{n+1}, V_{j+1/2}^{n+1})$ FROM PEK
$(K\Delta M)_j^{n+1} = \frac{1}{2}(\Delta M_{j-1/2} * K(T_j^{n+1}, V_{j-1/2}^{n+1}) + \Delta M_{j+1/2} * K(T_j^{n+1}, V_{j+1/2}^{n+1}))$
$R_j : 0$
$L_j^{n+1} = R_j^{2(\delta-1)}(T^4_{j-1/2} - T^4_{j+1/2}) / (K\Delta M)_j^{n+1}$
j : 1
17
$\frac{\partial}{\partial T_j^{n+1}} K(T_j^{n+1}, V_{j-1/2}^{n+1})$ FROM PEK
$\frac{\partial}{\partial T_j^{n+1}} K(T_j^{n+1}, V_{j-1/2}^{n+1}) = 0$
18
$\frac{\partial}{\partial T_j^{n+1}} K(T_j^{n+1}, V_{j+1/2}^{n+1})$ FROM PEK
$\frac{\partial (K\Delta M)_j^{n+1}}{\partial T_{j-1/2}^{n+1}} = \frac{1}{4}\left(\frac{T_{j-1/2}^{n+1}}{T_j^{n+1}}\right)^3 \left(\Delta M_{j+1/2}^{n+1} \frac{\partial}{\partial T_j^{n+1}} K(T_j^{n+1}, V_{j+1/2}^{n+1}) + \Delta M_{j-1/2}^{n+1} \frac{\partial}{\partial T_j^{n+1}} K(T_j^{n+1}, V_{j-1/2}^{n+1})\right)$
$\frac{\partial (K\Delta M)_j^{n+1}}{\partial T_{j+1/2}^{n+1}} = \frac{1}{4}\left(\frac{T_{j+1/2}^{n+1}}{T_j^{n+1}}\right)^3 \left(\Delta M_{j+1/2}^{n+1} \frac{\partial}{\partial T_j^{n+1}} K(T_j^{n+1}, V_{j+1/2}^{n+1}) + \Delta M_{j-1/2}^{n+1} \frac{\partial}{\partial T^{n+1}} K(T_j^{n+1}, V_{j-1/2}^{n+1})\right)$
20
j = j + 1
j : j*
RET

22. ROC(C)

ROC is called by EXEC. It calculates the coefficients for the forward backward substitution.

```
$IBFTC ROC      REF
       SUBROUTINE ROC(C)
C      COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C      SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
       DIMENSION C(1)
       J=1
       IF(R(1).LE.0.) GO TO 10
       R4=R(1)**(2*(DELTA-1))
       A=R4*4.*TEM3(2)+EL(1)*DKDMP(1)
       G(1)=A/KDM(1)
       CAPJ(1)=0.
   10  SIG(J+1)=2.*DMASS(J+1)*(EGM(J+1)-EG(J+1) + ((PR(J+1)+PRM(J+1))/2.
     1      +Q(J+1))*(VLM(J+1)-VL(J+1))) - THETA(J+1)
       CALL PEK(2,MAT(J+1),TEM(J+1),VL(J+1),J,1,DE,C)
       CALL PEK(1,MAT(J+1),TEM(J+1),VL(J+1),J,1,DP,C)
       CAPC(J+1)=2.*DMASS(J+1)*(DE+DP*((VL(J+1)-VLM(J+1))/2.))
       H(J+1)= CAPC(J+1)+DTP*G(J)
       CAPK(J+1)= SIG(J+1) + DTP*(EL(J)+ELM(J)-EL(J+1)-ELM(J+1)) +
     1      DTP*CAPJ(J)
  999 FORMAT (I4,8E16.8)
      IF (IC.GE.25) PRINT 999,J,SIG(J+1),EG(J+1),PR(J+1),THETA(J+1),DE,
     1  DP,CAPC(J+1),CAPK(J+1)
       IF(J.GT.JSTAR) RETURN
       R4=R(J+1)**(2*(DELTA-1))
       SAG=R4*(TEM4(J+1)-TEM4(J+2)) - KDM(J+1)*EL(J+1)
       A=R4*4.*TEM3(J+2)+EL(J+1)*DKDMP(J+1)
       B=R4*4.*TEM3(J+1)-EL(J+1)*DKDMM(J+1)
       G(J+1)=A*H(J+1)/(KDM(J+1)*H(J+1)+DTP*B)
       CAPJ(J+1)=(H(J+1)*SAG+B*CAPK(J+1))/
     1      (KDM(J+1)*H(J+1)+DTP*B)
      IF (IC.GE.25) PRINT 999,J,SAG,KDM(J+1),A,DKDMP(J+1),DKDMM(J+1),
     1 B,G(J+1),CAPJ(J+1)
       J=J+1
       GO TO 10
       END
```

ROC

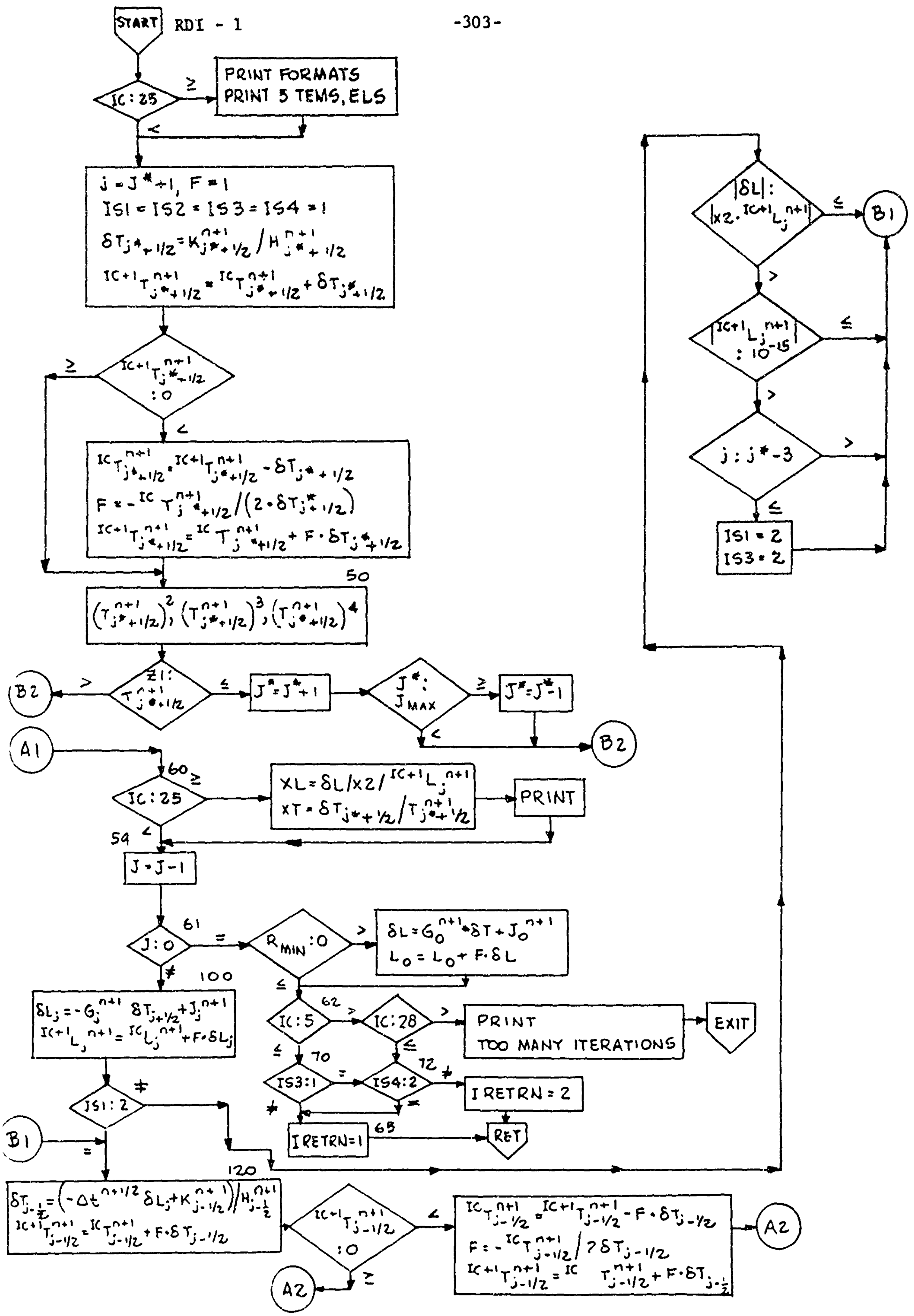

START
$j=1$
$R_0 : 0$
$R4 = R_0^{2(\delta-1)}$
$a_{1/2}^{n+1} = R4 * 4 * (T_{1/2}^{n+1})^3 + L_0 * \frac{\partial (K\Delta M)_0^{n+1}}{\partial T_{1/2}}$
$G_0^{n+1} = \frac{a_{1/2}^{n+1}}{(K\Delta M)_0^{n+1}}$, $J_0^{n+1} = 0$
10
$\sigma_{j-1/2}^{n+1} = 2. * \Delta M_{j-1/2} * \left[(E_{j-1/2}^{n} - E_{j-1/2}^{n+1}) + \left[\frac{(P_{j-1/2}^{n+1} + P_{j-1/2}^{n})}{2} + Q_{j-1/2}^{n+1/2} \right] * (V_{j-1/2}^{n} - V_{j-1/2}^{n+1}) \right] - \theta_{j-1/2}^{n+1}$
$\frac{\partial E_{j-1/2}^{n+1}}{\partial T_{j-1/2}^{n+1}}$ FROM PEK
$\frac{\partial P_{j-1/2}^{n+1}}{\partial T_{j-1/2}^{n+1}}$ FROM PEK
$C_{j-1/2}^{n+1} = 2. * \Delta M_{j-1/2}^{n+1} * \left[\frac{\partial E_{j-1/2}^{n+1}}{\partial T_{j-1/2}^{n+1}} + \frac{\partial P_{j-1/2}^{n+1}}{\partial T_{j-1/2}^{n+1}} * \frac{(V_{j-1/2}^{n+1} - V_{j-1/2}^{n})}{2} \right]$
$H_{j-1/2}^{n+1} = C_{j-1/2}^{n+1} + \Delta t^{n+1/2} * G_{j-1}^{n+1}$
$K_{j-1/2}^{n+1} = \sigma_{j-1/2}^{n+1} + \Delta t^{n+1/2} * (L_{j-1}^{n+1} + L_{j-1}^{n} - L_{j}^{n+1} - L_{j}^{n}) + \Delta t^{n+1/2} J_{j-1}^{n+1}$
IC : 25
PRINT
RET
$j : j^*$
$R4 = (R_j^{n+1})^{2(\delta-1)}$
$\sigma_j^{n+1} = R4 \left[(T_{j-1/2}^{n+1})^4 - (T_{j+1/2}^{n+1})^4 \right] - (K\Delta M)_j^{n+1} * L_j^{n+1}$
$a_{j+1/2}^{n+1} = 4 * R4 * (T_{j+1/2}^{n+1})^3 - L_j^{n+1} * \frac{\partial (K\Delta M)_j^{n+1}}{\partial T_{j+1/2}^{n+1}}$
$b_{j-1/2}^{n+1} = 4 * R4 * (T_{j-1/2}^{n+1})^3 - L_j^{n+1} * \frac{\partial (K\Delta M)_j^{n+1}}{\partial T_{j-1/2}^{n+1}}$
$G_j^{n+1} = \frac{a_{j+1/2}^{n+1} * H_{j-1/2}^{n+1}}{(K\Delta M)_j^{n+1} * H_{j-1/2}^{n+1} + \Delta t^{n+1/2} * b_{j-1/2}^{n+1}}$
$J_j^{n+1} = \frac{H_{j-1/2}^{n+1} * \sigma_j^{n+1} + b_{j-1/2}^{n+1} * K_{j-1/2}^{n+1}}{(K\Delta M)_j^{n+1} * H_{j-1/2}^{n+1} + \Delta t^{n+1/2} * b_{j-1/2}^{n+1}}$
IC : 25
PRINT
$j = j + 1$

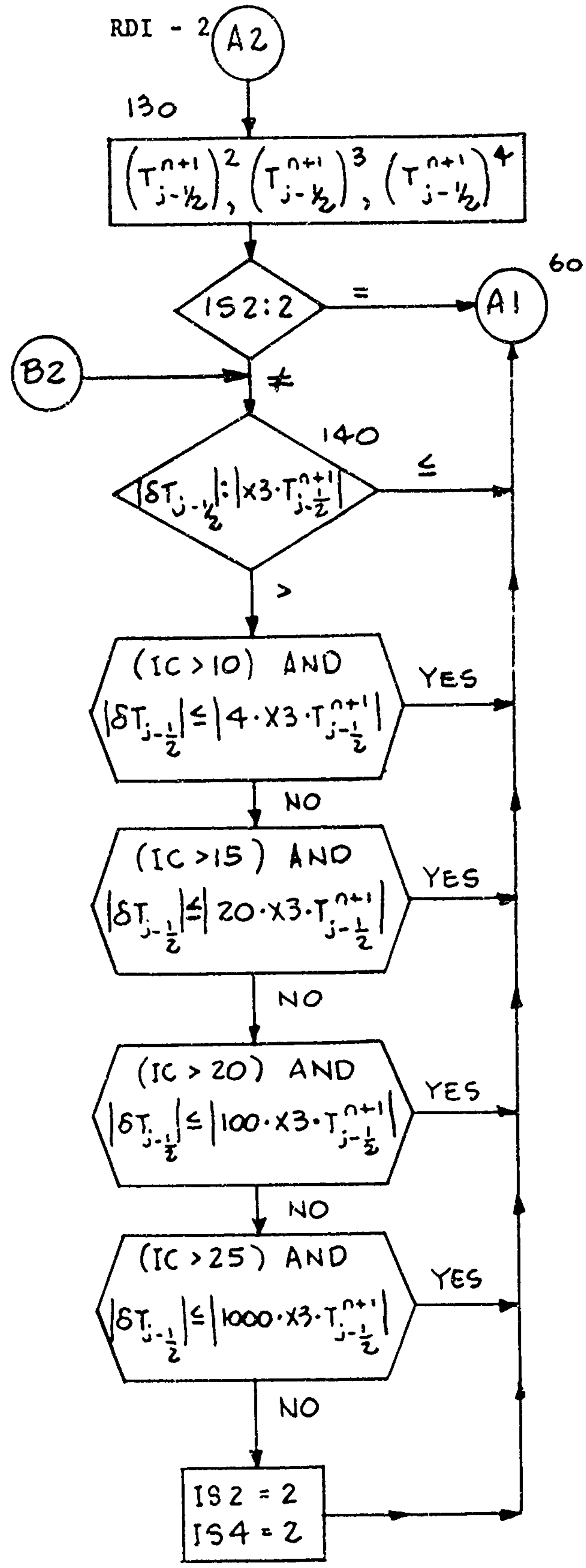
23. RDI(C)

RDI is called by EXEC. It calculates δT and δL and the new temperature and luminosity. RDI also determines whether T and L have converged or not.

```
$IBFTC RDI     REF
      SUBROUTINE RDI(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
      INTEGER  DELTA, REGNO, UNCGS, UNMKS
      REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
      J=JSTAR+1
      IF (IC.GE.25) PRINT 8000, TEM(J+1),TEM(J),TEM(J-1),TEM(J-2),
     1 TEM(J-3)
      IF (IC.GE.25) PRINT 8000, EL(J+1),EL(J),EL(J-1),EL(J-2),EL(J-3)
 8000 FORMAT (5E16.8)
      IF (IC.EQ.25) PRINT 7003
 7003 FORMAT (125H0IC,J,       DTEM,              T,               DL,
     1        L,             F,          CAPK,         H,            XL,
     2      XT)
      J=JSTAR+1
      F=1.
      IS1=1
      IS2=1
      IS3=1
      IS4=1
      DTEM=CAPK(J+1)/H(J+1)
      TEM(J+1)=TEM(J+1)+DTEM
      IF(TEM(J+1).GE.0.) GO TO 50
      TEM(J+1)=TEM(J+1)-DTEM
      F=-TEM(J+1)/(2.*DTEM)
      TEM(J+1)=TEM(J+1)+F*DTEM
  50  TEMSQ(J+1)=TEM(J+1)**2
      TEM3(J+1)=TEM(J+1) *TEMSQ(J+1)
      TEM4(J+1)=TEMSQ(J+1)**2
      IF(Z1.GT.TEM(J+1)) GO TO 140
      JSTAR=JSTAR+1
      IF(JSTAR.GE.JMAX) JSTAR=JSTAR-1
      GO TO 140
  60  IF (IC.LT.25) GO TO 59
      XL=DL/X2/EL(J+1)
      XT=DTEM/TEM(J+1)
     PRINT 7004,IC,J,DTEM,TEM(J+1),DL,EL(J+1),F,CAPK(J+1),H(J+1),XL,XT
 7004 FORMAT  (2I3,4E16.8,5E12.4)
  59  J=J-1
```

```
 61   IF (J.NE.0)  GO TO 100
      IF(RMIN.LE.0.) GO TO 62
      DL=-G(1)*DTEM+CAPJ(1)
      EL(1)=EL(1)+F*DL
 62   IF (IC.LE.5) GO TO 70
      IF (IC.LE.28) GO TO 72
      GO TO 9998
 70   IF (IS3.NE.1)  GO TO 65
72    IF (IS4.EQ.2)  GO TO 65
      IRETRN=2
      RETURN
  65  IRETRN=1
      RETURN
 100  DL=-G(J+1)*DTEM+CAPJ(J+1)
      EL(J+1)=EL(J+1)+F*DL
      IF(IS1.EQ.2) GO TO 120
      IF(ABS(DL).LE.ABS(X2*EL(J+1))) GO TO 120
      IF(ABS(EL(J+1)).LE.1.0E-15) GO TO 120
      IF(J.GT.JSTAR-3) GO TO 120
      IS1=2
      IS3=2
 120  DTEM=(-DTP*DL+CAPK(J+1))/H(J+1)
      TEM(J+1)=TEM(J+1)+F*DTEM
      IF(TEM(J+1).GE.0.) GO TO 130
      TEM(J+1)=TEM(J+1)-F*DTEM
      F=-TEM(J+1)/(2.*DTEM)
      TEM(J+1)=TEM(J+1)+F*DTEM
 130  TEMSQ(J+1)=TEM(J+1)**2
      TEM3(J+1)=TEM(J+1)*TEMSQ(J+1)
      TEM4(J+1)=TEMSQ(J+1)**2
      IF(IS2.EQ.2) GO TO 60
140   IF(ABS(DTEM).LE.ABS(X3*TEM(J+1))) GO TO 60
      IF (IC.GT.10.AND.ABS(DTEM).LE.ABS(4.*X3*TEM(J+1))) GO TO 60
      IF (IC.GT.15.AND.ABS(DTEM).LE.ABS(20.*X3*TEM(J+1))) GO TO 60
      IF (IC.GT.20.AND.ABS(DTEM).LE.ABS(100.*X3*TEM(J+1))) GO TO 60
      IF (IC.GT.25.AND.ABS(DTEM).LE.ABS(1000.*X3*TEM(J+1))) GO TO 60
      IS2=2
      IS4=2
      GO TO 60
9998  PRINT 7001
7001  FORMAT(20HOTOO MANY ITERATIONS)
      CALL EXIT
      END
```

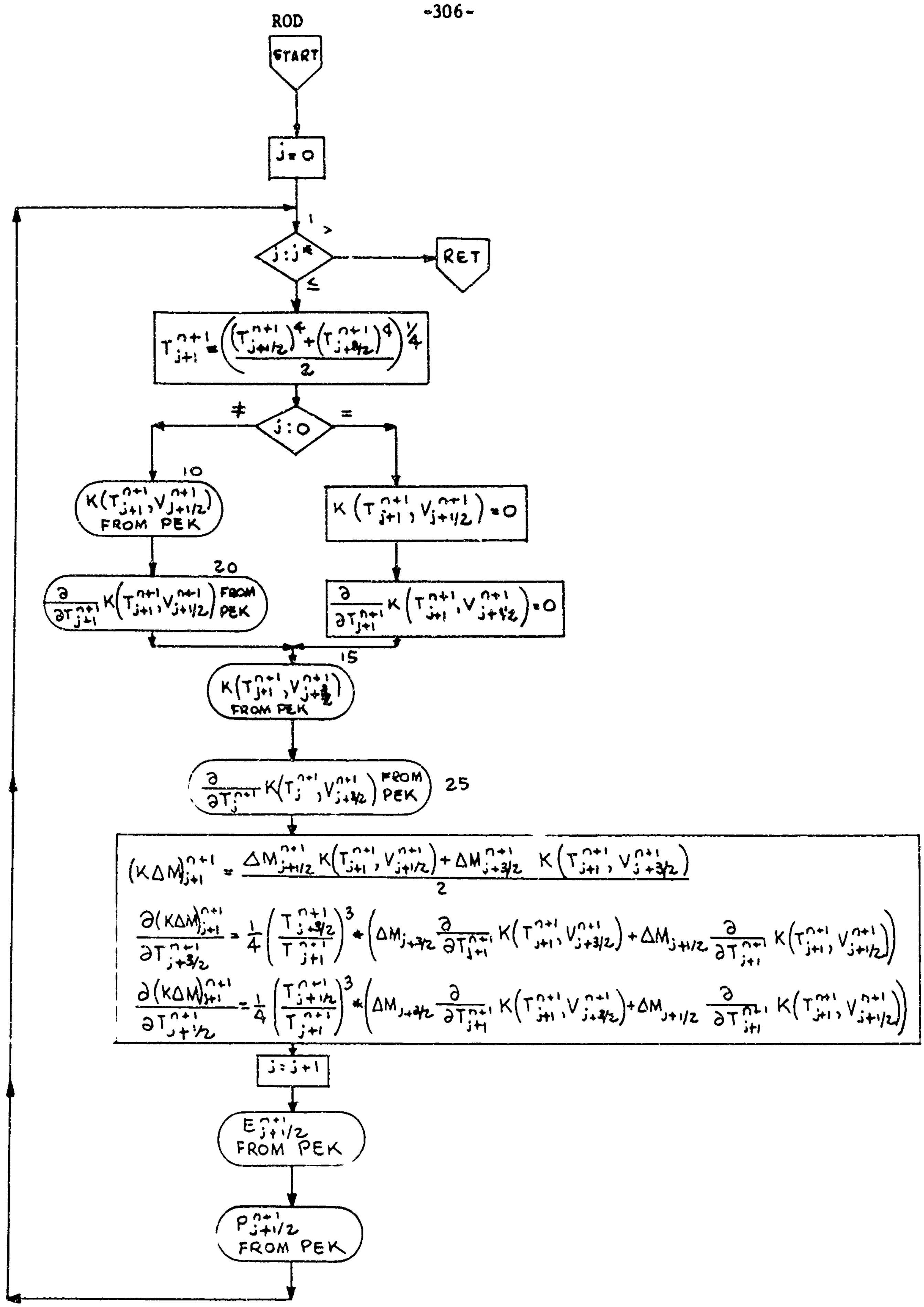

START
RDI - 1
IC : 25
PRINT FORMATS
PRINT 5 TEMS, ELS
j = J* + 1, F = 1
IS1 = IS2 = IS3 = IS4 = 1
50
60
54
J = J - 1
61
J : 0
RMIN : 0
100
62
IC : 5
IC : 28
PRINT
TOO MANY ITERATIONS
EXIT
70
72
IS3 : 1
IS4 : 2
IRETRN = 2
IRETRN = 1
65
RET
IS1 : 2
120
B1
B2
A1
A2
PRINT
J* : JMAX
j : j* - 3
IS1 = 2
IS3 = 2


RDI - 2
A2
130
$(T^{n+1}_{j-1/2})^2, (T^{n+1}_{j-1/2})^3, (T^{n+1}_{j-1/2})^4$
IS2:2
=
60
A1
B2
≠
140
$|\delta T_{j-1/2}| : |X3 \cdot T^{n+1}_{j-1/2}|$
≤
>
(IC > 10) AND
$|\delta T_{j-\frac{1}{2}}| \le |4 \cdot X3 \cdot T^{n+1}_{j-\frac{1}{2}}|$
YES
NO
(IC > 15) AND
$|\delta T_{j-\frac{1}{2}}| \le |20 \cdot X3 \cdot T^{n+1}_{j-\frac{1}{2}}|$
YES
NO
(IC > 20) AND
$|\delta T_{j-\frac{1}{2}}| \le |100 \cdot X3 \cdot T^{n+1}_{j-\frac{1}{2}}|$
YES
NO
(IC > 25) AND
$|\delta T_{j-\frac{1}{2}}| \le |1000 \cdot X3 \cdot T^{n+1}_{j-\frac{1}{2}}|$
YES
NO
IS2 = 2
IS4 = 2

24. ROD(C)

ROD is called by EXEC. ROD uses the new temperature and luminosity to calculate the new opacity, energy and pressure.

```
$IBFTC ROD      REF
      SUBROUTINE ROD(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
      INTEGER  DELTA, REGNO, UNCGS, UNMKS
      REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
      J=0
    1 IF(J.GT.JSTAR) RETURN
      TAM(J+1)=((TEM4(J+1)+TEM4(J+2))/2.)**.25
      IF(J.NE.0) GO TO 10
      KM(1)=0.
      DKMM=0.
      GO TO 15
   10 CALL PEK(3,MAT(J+1),TAM(J+1),VL(J+1),J,0,KM(J+1),C)
   20 CALL PEK(3,MAT(J+1),TAM(J+1),VL(J+1),J,1,DKMM,C)
   15 CALL PEK(3,MAT(J+2),TAM(J+1),VL(J+2),J,0,KP(J+1),C)
   25 CALL PEK(3,MAT(J+2),TAM(J+1),VL(J+2),J,1,DKMP,C)
      KDM(J+1)=(DMASS(J+1)*KM(J+1)+DMASS(J+2)*KP(J+1))*.5
      DKDMTM=DMASS(J+2)*DKMP+DMASS(J+1)*DKMM
      DKDMP(J+1)=.25*(TEM(J+2)/TAM(J+1))**3*DKDMTM
      DKDMM(J+1)=.25*(TEM(J+1)/TAM(J+1))**3*DKDMTM
      J=J+1
      CALL PEK(2,MAT(J+1),TEM(J+1),VL(J+1),J,0,EG(J+1),C)
      CALL PEK(1,MAT(J+1),TEM(J+1),VL(J+1),J,0,PR(J+1),C)
      GO TO 1
      END
```

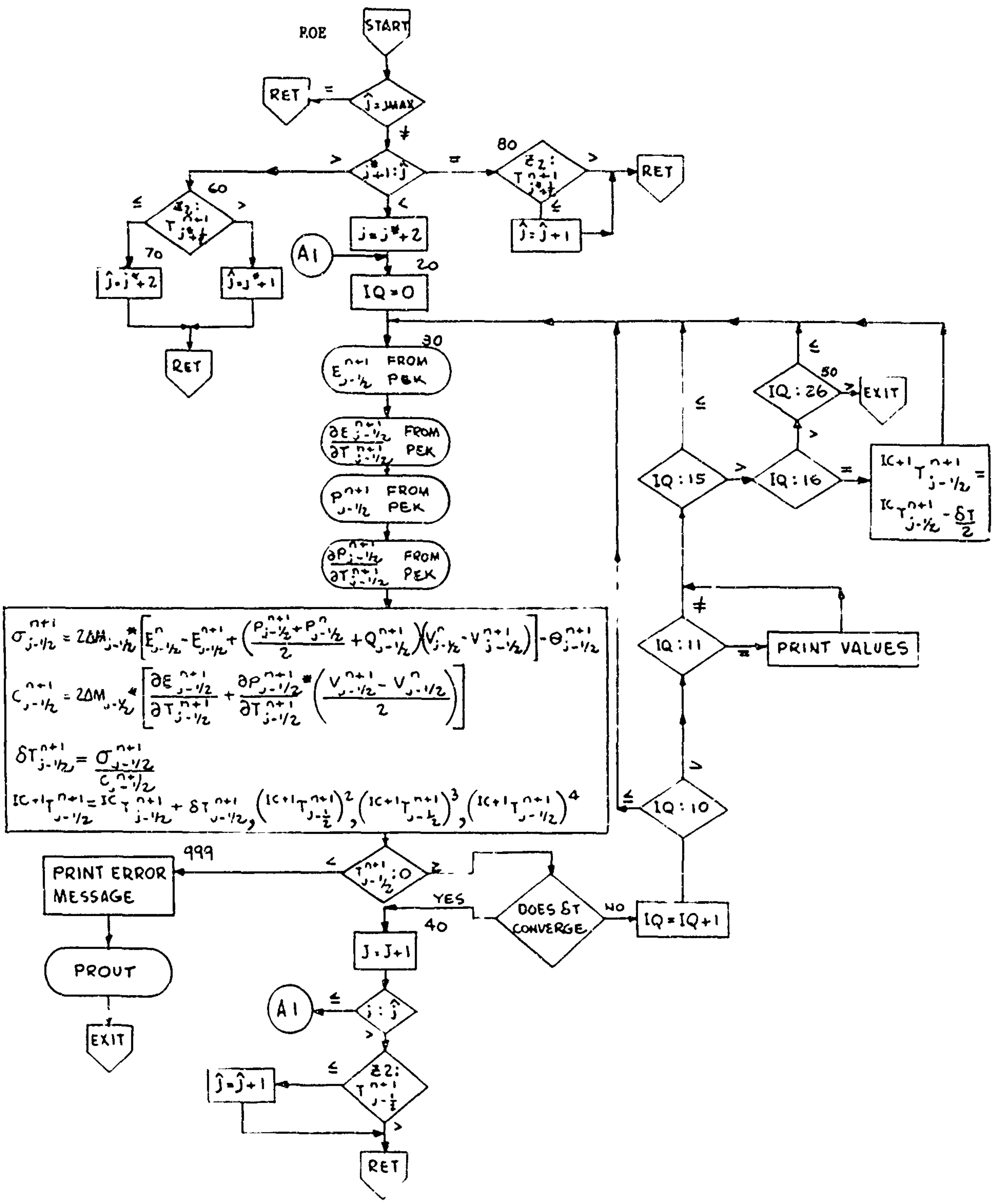

ROD
START
$j = 0$
$j : j^*$
$>$
$\le$
RET
$T_{j+1}^{n+1} = \left(\frac{(T_{j+1/2}^{n+1})^4 + (T_{j+3/2}^{n+1})^4}{2}\right)^{1/4}$
$j : 0$
$\neq$
$=$
10
$K(T_{j+1}^{n+1}, V_{j+1/2}^{n+1})$ FROM PEK
$K(T_{j+1}^{n+1}, V_{j+1/2}^{n+1}) = 0$
20
$\frac{\partial}{\partial T_{j+1}^{n+1}} K(T_{j+1}^{n+1}, V_{j+1/2}^{n+1})$ FROM PEK
$\frac{\partial}{\partial T_{j+1}^{n+1}} K(T_{j+1}^{n+1}, V_{j+1/2}^{n+1}) = 0$
15
$K(T_{j+1}^{n+1}, V_{j+3/2}^{n+1})$ FROM PEK
25
$\frac{\partial}{\partial T_j^{n+1}} K(T_j^{n+1}, V_{j+3/2}^{n+1})$ FROM PEK
$(K\Delta M)_{j+1}^{n+1} = \frac{\Delta M_{j+1/2}^{n+1} K(T_{j+1}^{n+1}, V_{j+1/2}^{n+1}) + \Delta M_{j+3/2}^{n+1} K(T_{j+1}^{n+1}, V_{j+3/2}^{n+1})}{2}$
$\frac{\partial (K\Delta M)_{j+1}^{n+1}}{\partial T_{j+3/2}^{n+1}} = \frac{1}{4}\left(\frac{T_{j+3/2}^{n+1}}{T_{j+1}^{n+1}}\right)^3 * \left(\Delta M_{j+3/2} \frac{\partial}{\partial T_{j+1}^{n+1}} K(T_{j+1}^{n+1}, V_{j+3/2}^{n+1}) + \Delta M_{j+1/2} \frac{\partial}{\partial T_{j+1}^{n+1}} K(T_{j+1}^{n+1}, V_{j+1/2}^{n+1})\right)$
$\frac{\partial (K\Delta M)_{j+1}^{n+1}}{\partial T_{j+1/2}^{n+1}} = \frac{1}{4}\left(\frac{T_{j+1/2}^{n+1}}{T_{j+1}^{n+1}}\right)^3 * \left(\Delta M_{j+3/2} \frac{\partial}{\partial T_{j+1}^{n+1}} K(T_{j+1}^{n+1}, V_{j+3/2}^{n+1}) + \Delta M_{j+1/2} \frac{\partial}{\partial T_{j+1}^{n+1}} K(T_{j+1}^{n+1}, V_{j+1/2}^{n+1})\right)$
$j = j+1$
$E_{j+1/2}^{n+1}$ FROM PEK
$P_{j+1/2}^{n+1}$ FROM PEK

25. ROE(C)

ROE is called by EXEC. It calculates temperature, energy and pressure for those zones between $j=j^{*}$ and $j=\hat{j}$.

```
$IBFTC ROE     REF
      SUBROUTINE ROE(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
      INTEGER  DELTA, REGNO, UNCGS, UNMKS
      REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
      IF(JHAT.EQ.JMAX) RETURN
      IF(JSTAR+1.GT.JHAT) GO TO 60
      IF(JSTAR+1.EQ.JHAT) GO TO 80
      J=JSTAR+2
   20 IQ=0
   30 CALL PEK(2,MAT(J+1),TEM(J+1),VL(J+1),J,0,EG(J+1),C)
      CALL PEK(2,MAT(J+1),TEM(J+1),VL(J+1),J,1,DE,C)
      CALL PEK(1,MAT(J+1),TEM(J+1),VL(J+1),J,0,PR(J+1),C)
      CALL PEK(1,MAT(J+1),TEM(J+1),VL(J+1),J,1,DP,C)
      SIG(J+1)=2.*DMASS(J+1)*(EGM(J+1)-EG(J+1)+((PR(J+1)+PRM(J+1))/2.
     1      +Q(J+1))*(VLM(J+1)-VL(J+1)))-THETA(J+1)
      CAPC(J+1)=2.*DMASS(J+1)*(DE+DP*((VL(J+1)-VLM(J+1))/2.))
      DTEM=SIG(J+1)/CAPC(J+1)
      TEM(J+1)=TEM(J+1)+DTEM
      TEMSQ(J+1)=TEM(J+1)**2
      TEM3(J+1)=TEMSQ(J+1)*TEM(J+1)
      TEM4(J+1)=TEMSQ(J+1)**2
      IF(TEM(J+1).LT.0.) GO TO 999
      IF (IQ.GT.20.AND.ABS(DTEM).LE.ABS(4.000*X1*TEM(J+1))) GO TO 40
      IF (IQ.GT.22.AND.ABS(DTEM).LE.ABS(20.00*X1*TEM(J+1))) GO TO 40
      IF (IQ.GT.24.AND.ABS(DTEM).LE.ABS(100.0*X1*TEM(J+1))) GO TO 40
      IF(ABS(DTEM).LE.ABS(X1*TEM(J+1))) GO TO 40
      IQ=IQ+1
      IF (IQ.LE.10) GO TO 30
      IF (IQ.EQ.11) WRITE (6,2000)
 2000 FORMAT (104H( J,       DTEM,            TEM(J+1),       EG(J+1),
     1       DE,          PR(J+1),             DP,          IQ)
      WRITE (6,1000) J,DTEM,TEM(J+1),EG(J+1),DE,PR(J+1),DP,IQ
 1000 FORMAT (I4,1P6E16.8,I4)
      IF (IQ.LE.15) GO TO 30
      IF (IQ.GT.16) GO TO 50
      TEM(J+1)=TEM(J+1)-DTEM/2.
      TEMSQ(J+1)=TEM(J+1)**2
      TEM3(J+1)=TEMSQ(J+1)*TEM(J+1)
      TEM4(J+1)=TEMSQ(J+1)**2
      GO TO 30
```

```
40     J=J+1
       IF(J.LE.JHAT) GO TO 20
       IF(Z2.GT.TEM(J+1)) RETURN
       JHAT=JHAT+1
       RETURN
50     IF (IQ.LE.26) GO TO 30
       CALL FXIT
  60   IF(Z2.LE.TEM(JSTAR+2)) GO TO 70
       JHAT=JSTAR+1
       RETURN
  70   JHAT=JSTAR+2
       RETURN
  80   IF(Z2.GT.TEM(JSTAR+2)) RETURN
       JHAT=JHAT+1
       RETURN
 999   PRINT 7000
7000 FORMAT(21HOTEMP. WENT NEG. ROE.)
       CALL PROUT (C)
       CALL EXIT
       END
```


ROE
START
RET
PRINT VALUES
PRINT ERROR MESSAGE
PROUT
EXIT
DOES δT CONVERGE
YES
NO
IQ = 0
IQ = IQ+1
IQ : 10
IQ : 11
IQ : 15
IQ : 16
IQ : 26
J = J+1
A1
999
40
20
30
50
60
70
80

26. TSRIMP(C)

TSRIMP is called by EXEC. It controls the size of Δt for implicit radiation problems.

```
$IBFTC TSRIMP  REF
       SUBROUTINE TSRIMP(C)
C      COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED H
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C      SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED H
      DIMENSION C(1)
       IF(ICK.EQ.0.AND.IH.EQ.0.AND.IP.EQ.0) GO TO 5
      DTM2 = DTP
      DTM1 = DT
      DTP =DTPS
      DT = DTS
    5  IR=1
      J=1
       JGAMMA=1
       IF(Z1.NE.0.) GO TO 10
       X10=DTP*2.
       GO TO 150
   10  X10=DTP*2.
   50  CALL PEK(2,MAT(J+1),TAM(J+1),VL(J+1),J,1,DE,C)
       X1OTRM=C5(IR)*DMESS(J+1)*KDM(J+1)*DE/(8.*R(J+1)**(2*(DELTA-1)
     1   *TAM(J+1)**3)
       X1OTRM=ABS(X1OTRM)
       IF(X1OTRM.GE.X10) GO TO 100
       JGAMMA=J
       X10=X1OTRM
  100 IF(J.GE.JSTAR) GO TO 150
      J=J+1
       IF(J.LE.JREG(IR))GO TO 50
       IR=IR+1
      GO TO 50
  150 J=1
      REGNO=1
      X20=0.
      X30=0.
  160 XX=R(J+1)**(2*(DELTA-1))*PR(J+1)*C3(REGNO)/(VL(J+1)*DMASS(J+1)
      IF (XX.LE.X20) GO TO 200
      X20=XX
       JOMEGA=J
  200 IF (VLM(J+1)-VL(J+1).LE.0.) GO TO 220
      XX=(VLM(J+1)-VL(J+1))*C4(REGNO)/VL(J+1)
      IF (XX.GT.X30) GO TO 240
  220 IF (J.GE.JHAT) GO TO 260
      J=J+1
      IF (J.LE.JREG(REGNO) ) GO TO 160
      REGNO=REGNO+1
      GO TO 160
```

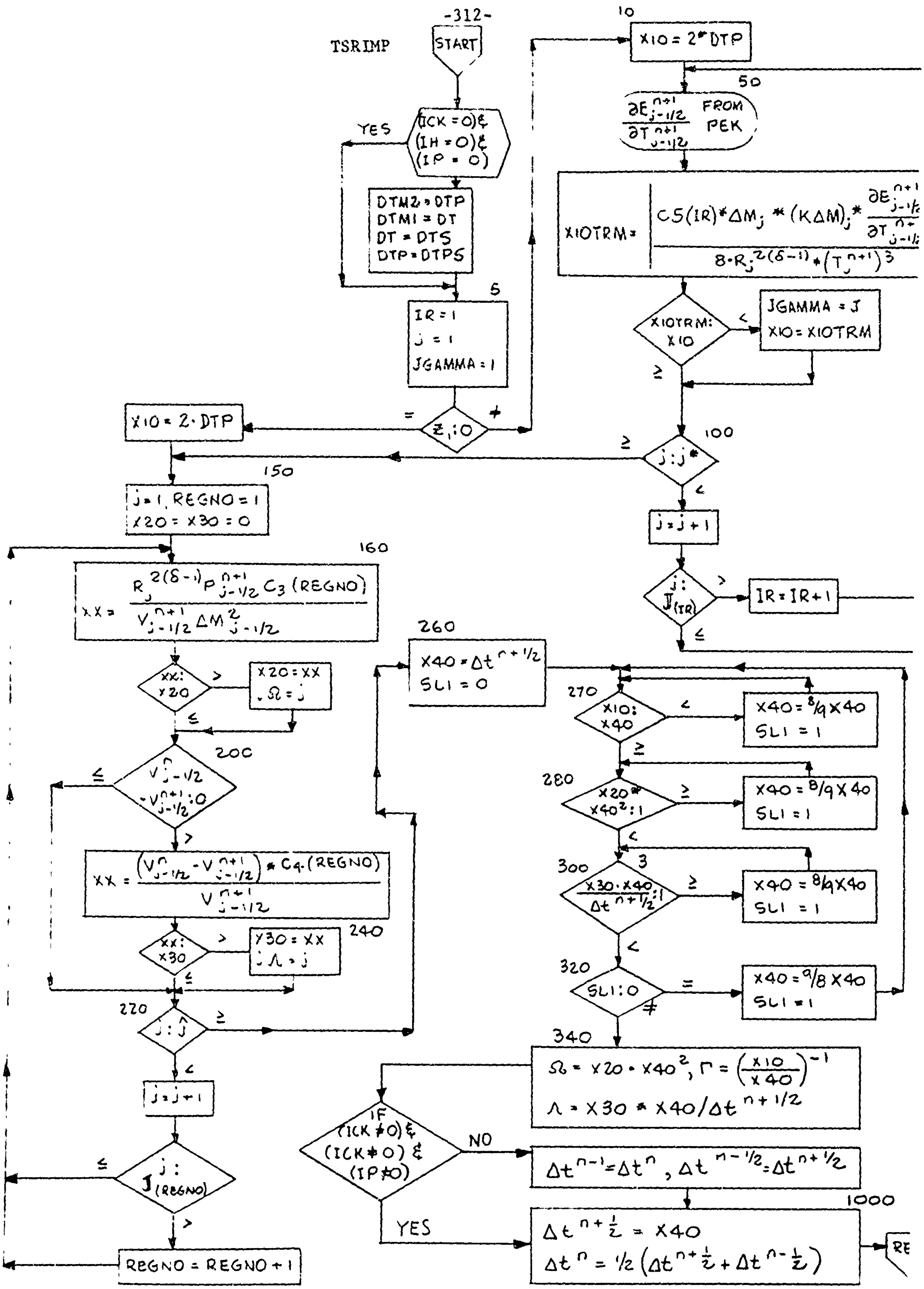
```
  240 X30=XX
      JLAM=J
      GO TO 220
  260 X40=DTP
      SL1=0.
  270 IF(X10.GE.X40) GO TO 280
      X40=8.*X40/9.
      SL1=1.
      GO TO 270
  280 IF (X20*X40**2.LT.1.) GO TO 300
      X40= 8.*X40/9.
      SL1=1.
      GO TO 280
  300 IF (X30*X40/DTP.LT.1.) GO TO 320
      X40=8.*X40/9.
      SL1=1.
      GO TO 300
  320 IF (SL1.NE.0.) GO TO 340
      X40=9.*X40/8.
      SL1=1.
      GO TO 270
  340 OMEGA=X20*X40**2
      AMBDA=X30*X40/DTP
      GAMMA=X40/X10
      IF (ICK.NE.0.AND.IH.NE.0.AND.IP.NE.0) GO TO 1000
      DTM1=DT
      DTM2=DTP
 1000 DTP = X40
      DT= .5*(DTP+DTM2)
      RETURN
      END
```

27. POR

POR is called by EXEC. It prints one line of output at the end of each cycle.

```
$IBFTC POR      REF
      SUBROUTINE POR
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
      WRITE(6,7000) N,TM,DTM2,AMBDA,JLAM,OMEGA,JOMEGA,GAMMA,JGAMMA,
     1  JO, JSTAR, JHAT, IC
 7000 FORMAT (I6,2E16.6,E14.4,I6,E14.4,I6,E14.4,5I6)
      RETURN
      END
```

TSRIMP


START
(ICK = 0) & (IH = 0) & (IP = 0)
YES
DTM2 = DTP
DTM1 = DT
DT = DTS
DTP = DTPS
5
IR = 1
j = 1
JGAMMA = 1
Z, : 0
X10 = 2·DTP
10
X10 = 2*DTP
50
FROM PEK
X10TRM =
8·R
JGAMMA = J
X10 = X10TRM
X10TRM : X10
100
j : j*
j = j + 1
IR = IR + 1
150
j = 1, REGNO = 1
X20 = X30 = 0
160
XX =
C3 (REGNO)
XX : X20
X20 = XX
200
C4 (REGNO)
XX : X30
X30 = XX
240
220
j = j + 1
REGNO = REGNO + 1
260
SL1 = 0
270
X10 : X40
X40 = 8/9 X40
SL1 = 1
280
300
320
SL1 : 0
X40 = 9/8 X40
340
X20 · X40
X30 * X40
IF (ICK ≠ 0) & (ICK ≠ 0) & (IP ≠ 0)
NO
YES
1000
X40
RE

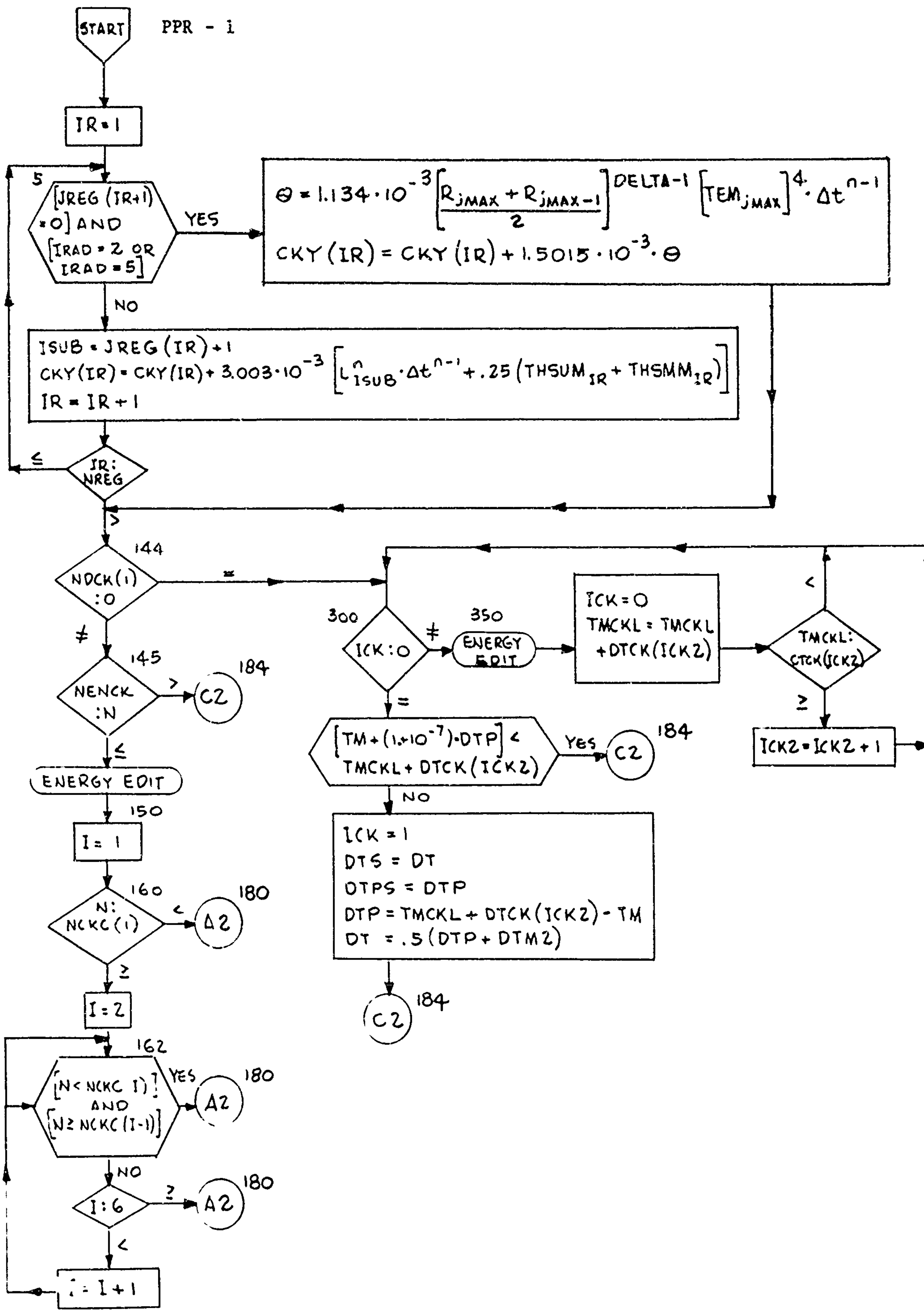
28. PPR(C)

PPR is called by EXEC. It determines if a print out, energy edit or history edit is to be taken at the time, and if so calls the appropriate routine.

```
$IBFTC PPR     REF
      SUBROUTINE PPR(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
       INTEGER  DELTA, REGNC, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
      IR = 1
    5  IF (JREG(IR+1).EQ.0.AND.(IRAD.EQ.2.OR.IRAD.EQ.5)) GO TO 10
       ISUB=JREG(IR)+1
       CKY(IR)=CKY(IR)+(ELM(ISUB)*DTM1+.25*(THSUM(IR)+THSMM(IR)))
     1  *3.003E-3
      IR = IR +1
      IF(IR.GT.NREG)  GO TO 144
      GO TO 5
   10  THETA=1.134E-3*((R(JMAX)+R(JMAX-1))/2.)**(DELTA-1)*TEM(JMAX)***4*
     1  DTM1
       CKY(IR)=CKY(IR)+THETA*1.5015E-3
  144  IF(NDCK(1).EQ.0) GO TO 300
  145 IF (NENCK.GT.N) GO TO 184
      CALL ECHECK
  150 I=1
  160 IF (N.LT.NCKC(1) ) GO TO 180
      I=2
  162 IF (N.LT.NCKC(I).AND.N.GE.NCKC(I-1)) GO TO 180
      IF (I.GE.6) GO TO 180
      I=I+1
      GO TO 162
  180 NENCK=NENCK+NDCK(I)
  184  IF(NDH(1).EQ.0) GO TO 400
  185 IF (NHIST.GT.N) GO TO 94
      CALL HIST
  190 I=1
  200 IF (N.LT.NHC(1) ) GO TO 220
      I=2
  202 IF (N.LT.NHC(I).AND.N.GE.NHC(I-1)) GO TO 220
      IF (I.GE.6) GO TO 220
      I=I+1
      GO TO 202
  220 NHIST=NHIST+NDH(I)
   94  IF(NDP(1).EQ.0) GO TO 500
   95 IF (NFRT.GT.N) GO TO 225
      CALL PROUT(C)
  100 I=1
```

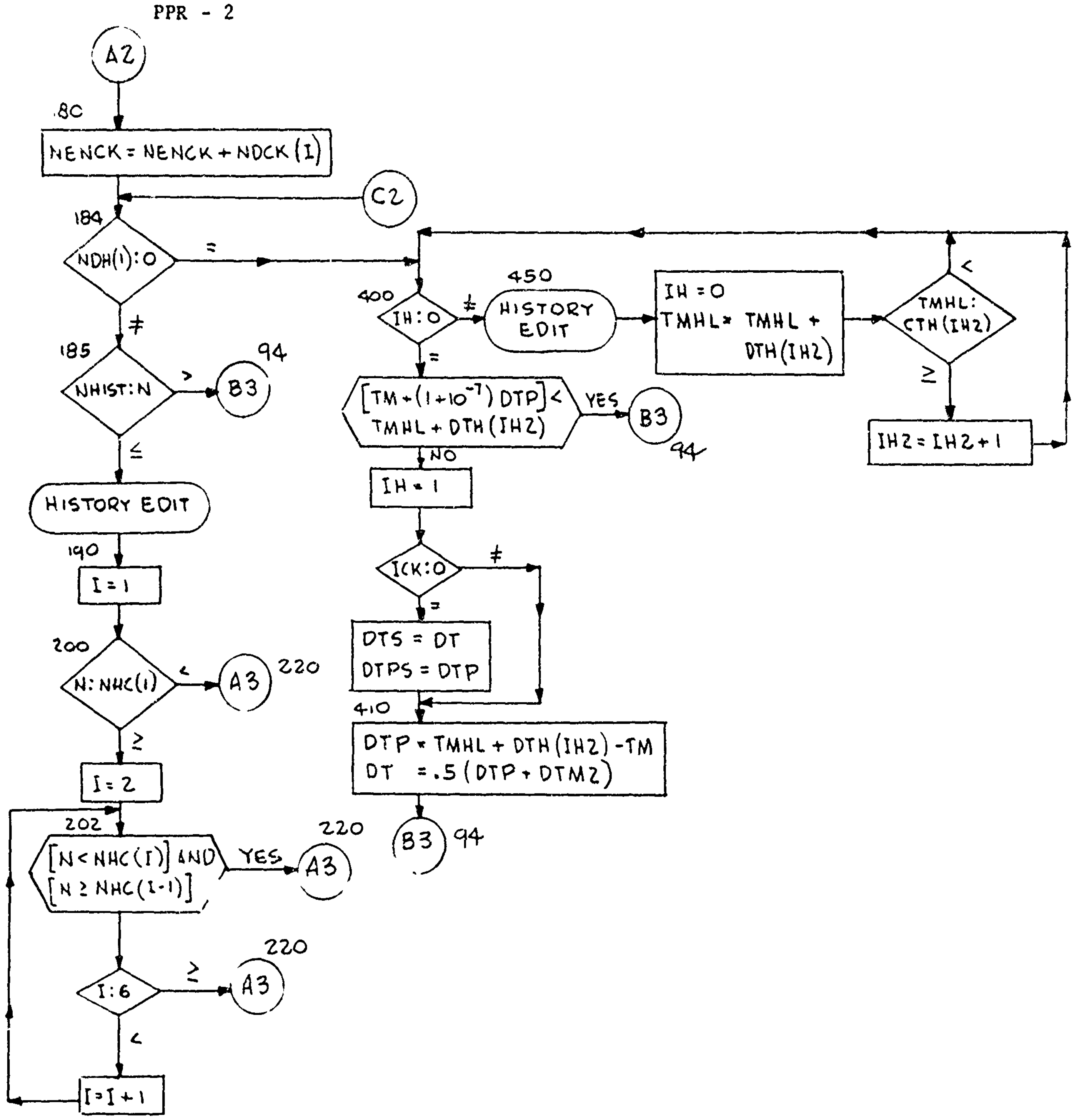
```
120  IF (N.LT.NPC(1)) GO TO 140
     I=2
122  IF (N.LT.NPC(I).AND.N.GE.NPC(I-1)) GO TO 140
     IF (I.GE.6) GO TO 140
     I=I+1
     GO TO 122
 140 NPRT=NPRT+NDP(I)
225  RETURN
 300  IF(ICK.NE.0) GO TO 350
      IF (TM+DTP*(1.+1.E-7).LT.TMCKL+DTCK(ICK2)) GO TO 184
      ICK=1
      DTS=DT
      DTPS=DTP
      DTP=TMCKL+DTCK(ICK2)-TM
      DT=.5*(DTP+DTM2)
      GO TO 184
 350  CALL ECHECK
      ICK=0
      TMCKL=TMCKL+DTCK(ICK2)
      IF(TMCKL.LT.CTCK(ICK2))GO TO 300
      ICK2=ICK2+1
      GO TO 300
 400  IF(IH.NE.0) GO TO 450
      IF(TM+DTP*(1.+1.E-7).LT.TMHL+DTH(IH2))GO TO 94
      IH=1
      IF(ICK.NE.0) GO TO 410
      DTS=DT
      DTPS=DTP
 410  DTP=TMHL+DTH(IH2)-TM
      DT=.5*(DTP+DTM2)
      GO TO 94
 450  CALL HIST
      IH=0
      TMHL=TMHL+DTH(IH2)
      IF(TMHL.LT.CTH(IH2)) GO TO 400
      IH2=IH2+1
      GO TO 400
 500  IF(IP.NE.0) GO TO 550
      IF(TM+DTP*(1.+1.E-7).LT.TMPL+DTPR(IP2)) GO TO 225
      IP=1
      IF(ICK.NE.0.OR.IH.NE.0) GO TO 510
      DTS=DT
      DTPS=DTP
 510  DTP=TMPL+DTPR(IP2)-TM
      DT=.5*(DTP+DTM2)
      GO TO 225
 550 CALL PROUT(C)
      IP=0
      TMPL=TMPL+DTPR(IP2)
      IF(TMPL.LT.CTP(IP2)) GO TO 500
      IP2=IP2+1
      GO TO 500
     END
```

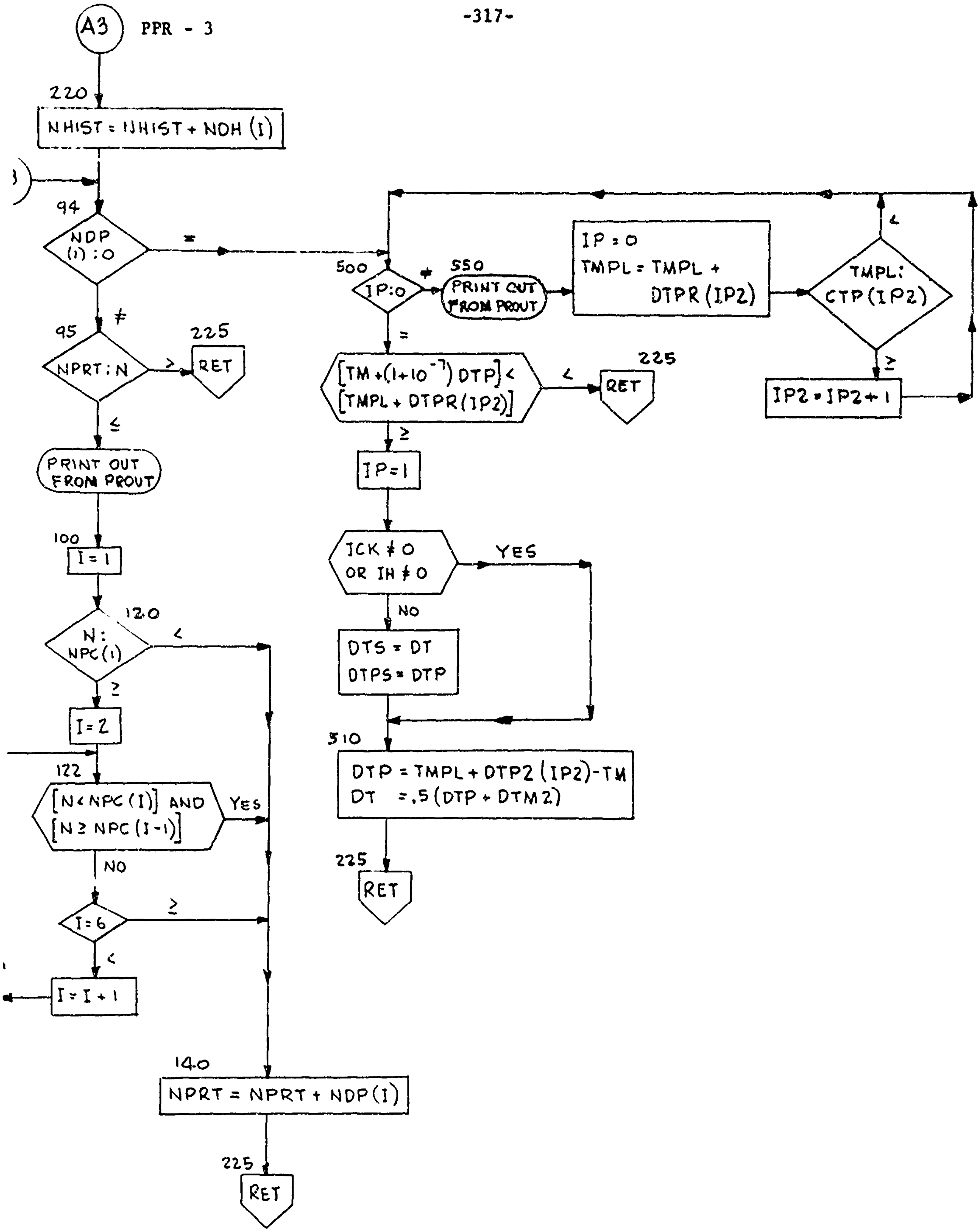
PPR - 1



START
IR = 1
5
[JREG (IR+1) = 0] AND [IRAD = 2 OR IRAD = 5]
YES
$\Theta = 1.134 \cdot 10^{-3} \left[\frac{R_{jMAX} + R_{jMAX-1}}{2}\right]^{DELTA-1} \left[TEM_{jMAX}\right]^{4} \cdot \Delta t^{n-1}$
$CKY(IR) = CKY(IR) + 1.5015 \cdot 10^{-3} \cdot \Theta$
NO
ISUB = JREG (IR) + 1
$CKY(IR) = CKY(IR) + 3.003 \cdot 10^{-3} \left[L^{n}_{ISUB} \cdot \Delta t^{n-1} + .25 (THSUM_{IR} + THSMM_{IR})\right]$
IR = IR + 1
IR : NREG
≤
>
144
NDCK(1) : 0
=
≠
145
NENCK : N
>
C2
184
≤
ENERGY EDIT
150
I = 1
160
N : NCKC(1)
<
A2
180
≥
I = 2
162
[N < NCKC (I)] AND [N ≥ NCKC (I-1)]
YES
A2
180
NO
I : 6
≥
A2
180
<
I = I + 1
300
ICK : 0
≠
350
ENERGY EDIT
ICK = 0
TMCKL = TMCKL + DTCK(ICK2)
TMCKL : CTCK(ICK2)
<
≥
ICK2 = ICK2 + 1
=
$[TM + (1.+10^{-7}) \cdot DTP] <$ TMCKL + DTCK(ICK2)
YES
C2
184
NO
ICK = 1
DTS = DT
DTPS = DTP
DTP = TMCKL + DTCK(ICK2) - TM
DT = .5(DTP + DTM2)
C2
184

PPR - 2


A2
180
NENCK = NENCK + NDCK (I)
C2
184
NDH(I):0
=
≠
185
NHIST:N
>
B3
94
≤
HISTORY EDIT
190
I = 1
200
N: NHC(I)
<
A3
220
≥
I = 2
202
[N < NHC(I)] AND [N ≥ NHC(I-1)]
YES
A3
220
I:6
≥
A3
220
<
I = I + 1
400
IH:0
≠
450
HISTORY EDIT
IH = 0
TMHL = TMHL + DTH(IH2)
TMHL: CTH(IH2)
<
≥
IH2 = IH2 + 1
=
[TM + (1+10⁻⁷) DTP] < TMHL + DTH(IH2)
YES
B3
94
NO
IH = 1
ICK:0
≠
=
DTS = DT
DTPS = DTP
410
DTP = TMHL + DTH(IH2) - TM
DT = .5 (DTP + DTM2)
B3
94


A3
PPR - 3
220
NHIST = NHIST + NDH (I)
94
NDP (I) : 0
=
≠
95
NPRT : N
>
225
RET
≤
PRINT OUT FROM PROUT
100
I = 1
120
N : NPC(I)
<
≥
I = 2
122
[N < NPC (I)] AND [N ≥ NPC (I-1)]
YES
NO
I : 6
≥
<
I = I + 1
140
NPRT = NPRT + NDP(I)
225
RET
500
IP : 0
≠
550
PRINT OUT FROM PROUT
IP = 0
TMPL = TMPL + DTPR (IP2)
TMPL : CTP (IP2)
<
≥
IP2 = IP2 + 1
=
[TM + (1+10^-7) DTP] < [TMPL + DTPR(IP2)]
<
225
RET
≥
IP = 1
ICK ≠ 0 OR IH ≠ 0
YES
NO
DTS = DT
DTPS = DTP
510
DTP = TMPL + DTP2 (IP2) - TM
DT = .5 (DTP + DTM2)
225
RET

29. HIST

HIST is called by PPR. It writes a history edit on FORTRAN logical tape 12.

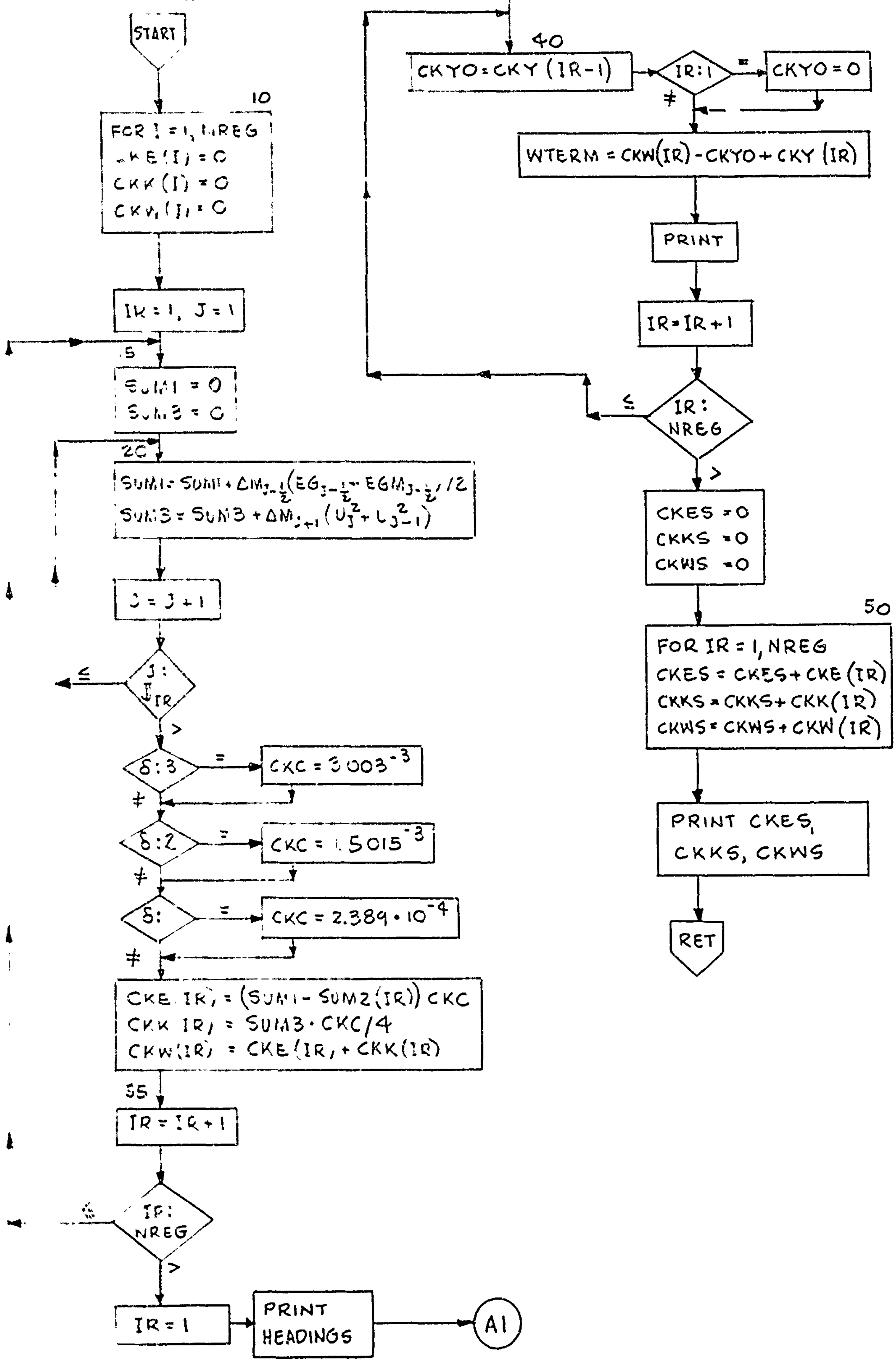
```
$IBFTC HIST    REF
       SUBROUTINE HIST
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED H
       INTEGER  DELTA, REGNO, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED H
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
      WRITE (12) NREG,JMAX,NRSRCE,NZSRCE,NEMIN,NEMAX,NKMIN,NKMAX,NPM
     1 NPMAX,NTMIN,NTMAX,NUMIN,NUMAX,DT,DTP,DELTA,REGNO,N,NF,JZ,DRC,
     2 Z1,Z2,X1,X2,X3,X4,X5,X6,J0,J0M,J0S,JL,JSTAR,JHAT,UNCGS,UNMKS,
     3 TM,RMIN,RMAX
      JMAX2=JMAX+2
      WRITE (12) (R(I),U(I),TEM(I),TAM(I),VL(I),VLM(I),PR(I),PRM(I),
     1 EG(I),EGM(I),KP(I), KM(I),DMASS(I),DMESS(I), TEMSQ(I),TEM3(I)
     2 TEM4(I),KDM(I),EL(I),ELM(I),MAT(I),Q(I),I=1,JMAX2)
       WRITE (12) (RRG(I),JREG(I),C1(I),C2(I),C3(I),C4(I),C5(I),EO(I
     1 CKY(I),SUM2(I),I=1,15),MEOS,IDEOS
      WRITE (12) (NDH(I),NHC(I),NDP(I),NPC(I),NDCK(I),NCKC(I),EMIN(I
     1 EMAX(I),KMIN(I),KMAX(I),PMIN(I),PMAX(I),TMIN(I),TMAX(I),UMIN(
     2 UMAX(I),TEMIN(I),TEMAX(I),TKMIN(I),TKMAX(I),TPMIN(I),TPMAX(I)
     3 TTMIN(I),TTMAX(I),TUMIN(I),TUMAX(I),DTH(I),CTH(I),DTPR(I),CTP
     4 DTCK(I),CTCK(I),I=1,6)
      WRITE (12) ((ERS(I,K),ES(I,K),TMRS(I,K),TMS(I,K),I=1,6),RS(K),
     1 JS(K),NRS(K),NZS(K),K=1,10)
       J=123456
       WRITE (12) J
       BACKSPACE 12
       PRINT 7000, N
 7000 FORMAT(22H0HISTORY EDIT AT CYCLE I6,1H.)
       RETURN
       END
```

30. ECHECK

ECHECK is called by PPR. It calculates the total energy in the problem and prints.

```
$IBFTC ECHECK  REF
      SUBROUTINE ECHECK
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      INTEGER  DELTA, REGNO, UNCGS, UNMKS
      REAL  KMIN, KMAX, KP, KM, KDM
      DIMENSION CKE(15), CKK(15), CKW(15)
      DO 10 I=1,NREG
      CKE(I)=0.
      CKK(I)=0.
   10 CKW(I)=0.
      IR=1
      J=1
   15 SUM1=0.
      SUM3=0.
   20 SUM1=SUM1+.5*DMASS(J+1)*(EG(J+1)+EGM(J+1))
      SUM3=SUM3+DMASS(J+1)*(U(J)**2+U(J+1)**2)
      J=J+1
      IF(J.LE.JREG(IR)) GO TO 20
      IF(DELTA.EQ.3) CKC=3.003E-3
      IF(DELTA.EQ.2) CKC=1.5015E-3
      IF(DELTA.EQ.1) CKC=2.389E-4
      CKE(IR)=(SUM1-SUM2(IR))*CKC
      CKK(IR)=SUM3*CKC/4.
      CKW(IR)=CKE(IR)+CKK(IR)
   35 IR=IR+1
      IF(IR.LE.NREG) GO TO 15
      IR=1
      PRINT 7000
 7000 FORMAT(1H0,8X,1HE,15X,1HK,15X,1HW,15X,1HY,13X,5HW-Y+Y,13X,4HJREG)
   40 CKYO=CKY(IR-1)
      IF(IR.EQ.1) CKYO=0.
      WTERM=CKW(IR)-CKYO+CKY(IR)
      PRINT 7001,CKE(IR),CKK(IR),CKW(IR),CKY(IR),WTERM,JREG(IR)
 7001 FORMAT(1H 5E16.6,I10,E22.6,E16.6)
      IR=IR+1
      IF(IR.LE.NREG) GO TO 40
      CKES=0.
      CKKS=0.
      CKWS=0.
      DO 50 IR=1,NREG
      CKES=CKES+CKE(IR)
      CKKS=CKKS+CKK(IR)
   50 CKWS=CKWS+CKW(IR)
      PRINT 7001, CKES,CKKS,CKWS
      RETURN
      END
```

ECHECK


START
10
FOR I = 1, NREG
CKE(I) = 0
CKK(I) = 0
CKW(I) = 0
IR = 1, J = 1
5
SUM1 = 0
SUM3 = 0
20
SUM1 = SUM1 + ΔM(J-1/2)(EG(J-1/2) - EGM(J-1/2))/2
SUM3 = SUM3 + ΔM(J+1)(U(J)^2 + U(J-1)^2)
J = J + 1
J : J(IR)
≤
>
δ : 3
=
CKC = 3.003^-3
≠
δ : 2
=
CKC = 1.5015^-3
≠
δ :
=
CKC = 2.389 · 10^-4
≠
CKE(IR) = (SUM1 - SUM2(IR)) CKC
CKK(IR) = SUM3 · CKC/4
CKW(IR) = CKE(IR) + CKK(IR)
35
IR = IR + 1
IR : NREG
≤
>
IR = 1
PRINT HEADINGS
A1
A1
40
CKYO = CKY(IR-1)
IR : 1
=
CKYO = 0
≠
WTERM = CKW(IR) - CKYO + CKY(IR)
PRINT
IR = IR + 1
IR : NREG
≤
>
CKES = 0
CKKS = 0
CKWS = 0
50
FOR IR = 1, NREG
CKES = CKES + CKE(IR)
CKKS = CKKS + CKK(IR)
CKWS = CKWS + CKW(IR)
PRINT CKES, CKKS, CKWS
RET

31. PROUT(C)

PROUT is called by PPR. It is a MAP code which prints the variables specified by the output description deck. It calls upon those subroutines COUT1, COUT2, ..., COUT25 corresponding to the number of the variable desired to compute if necessary and to scale the variable.

In FORTRAN version the user must control his own output and therefore must write his own PROUT.

(Test Case 1 only)

```
$IBFTC PROUT    REF
      SUBROUTINE PROUT(C)
C     COMMON CARD  LABELED /IKA2/ GROUP TO BE PLACED HERE
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
      DIMENSION RH(202)
      JMAX2 = JMAX+2
      DO 500 J=1,JMAX2
      RH(J) = 1./VL(J)
  500 TEM(J) = .139*EG(J)
      WRITE(6,101)
  101 FORMAT (3H0 J,6X,6HRADIUS,9X,8HVELOCITY,8X,7HDENSITY,9X,4HTEMP,
     1  10X,6HINTENG,8X,8HPRESSURE,8X,6HARTVIS,10X,4HMASS )
      K=0
      WRITE (6,102) K,R(1),U(1),RH(1),TEM(1),EG(1),PR(1),Q(1),DMASS(1)
      I=1
      J=2
   20 WRITE (6,103) MAT(J)
  103 FORMAT (13H0MATERIAL    I4)
   10 K=J-1
      WRITE (6,102) K,R(J),U(J),RH(J),TEM(J),EG(J),PR(J),Q(J),DMASS(J)
  102 FORMAT (I3,1PE15.5,1P7E15.3)
      J=J+1
      IF (J.GT.JHAT+3) GO TO 30
      IF (J.LE.JREG(I)+1) GO TO 10
      I=I+1
      IF (I.LE.NREG) GO TO 20
   30 WRITE (6,104)
C
  104 FORMAT (6H0    N,10X,4HTIME ,12X,2HDT ,11X,6HLAMBDA,5X,4HJLAM ,6X,
C
     1 5HOMEGA ,4X,6HJOMEGA,6X,5HGAMMA,4X,4HJGAM ,3X,2HJ0,2X,5HJSTAR,2X,
C
     2 4HJHAT ,3X,2HIC )
C
      RETURN
      END
```

32. COUT1(J,IF,C), COUT2(J,IF,C), ..., COUT25(J,IF,C) (RAND version only)

These function type subroutines are called by PROUT. They correspond to the variables or functions 1, 2, ..., 25 in the output description deck. They compute, if necessary, and scale the output vari le desired.

33. CZR(C)

CZR is called by EXEC. It accomplishes the combining and adding of zones. If the combining is of the type in which zones are inserted at the righthand side of the problem, (indicated by JL < 0) maintaining an essentially constant R_{jmax}, CZR calls two subroutines RBOUND and PBOUND to determine the density and pressure of the zone which is to be inserted.

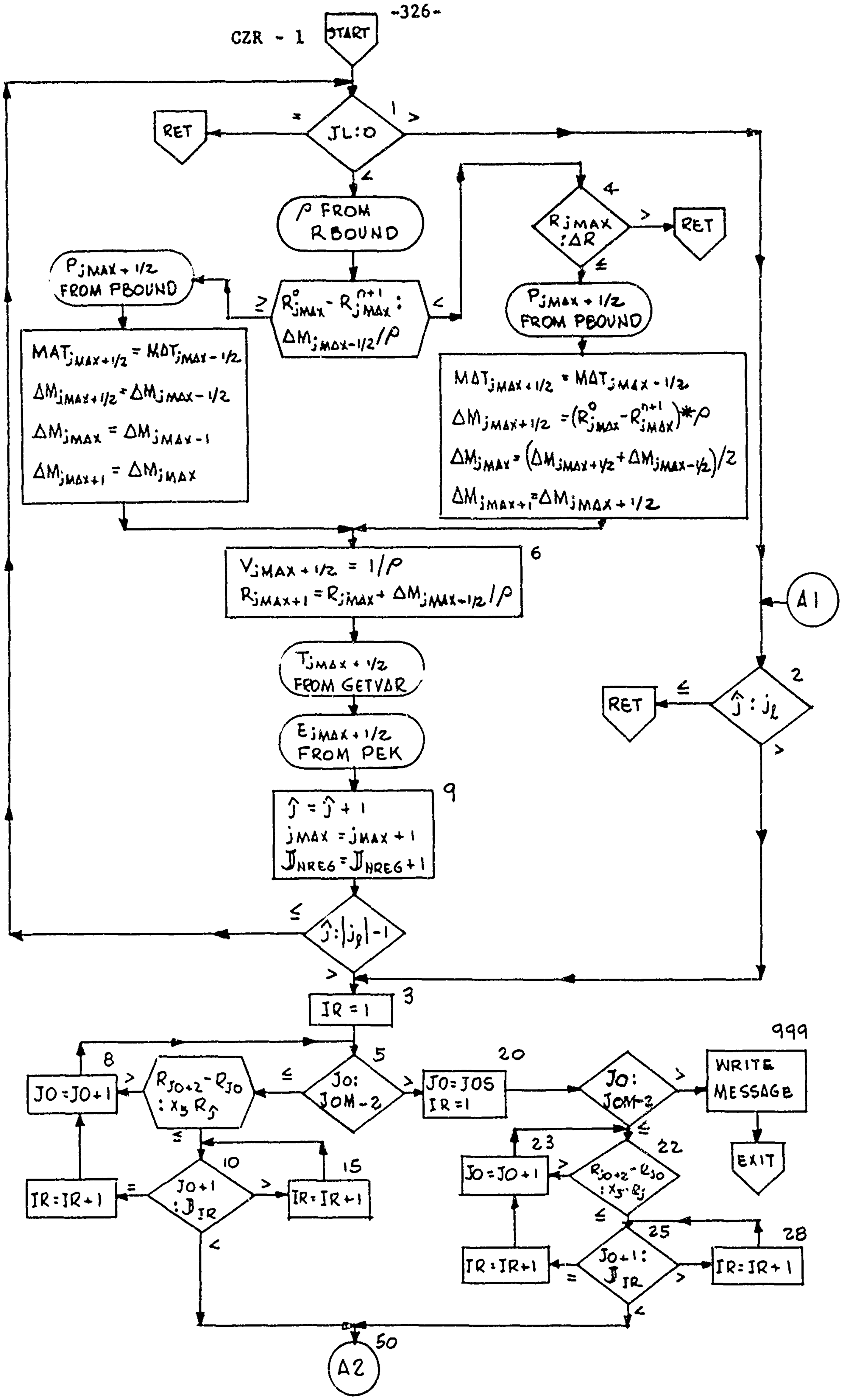
```
$IBFTC CZR     REF
      SUBROUTINE CZR(C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HI
      INTEGER  DELTA, REGNO, UNCGS, UNMKS
      REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HI
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
    1 IF(JL.EQ.0) RETURN
      DIMENSION C(1)
      IF(JL.GT.0) GO TO 2
      CALL RBOUND(TM,RHO)
      IF((RMAX-R(JMAX+1)).LT.(DMASS(JMAX+1)/RHO)) GO TO 4
      CALL PBOUND(TM,PR(JMAX+2))
      MAT(JMAX+2)=MAT(JMAX+1)
      DMASS(JMAX+2)=DMASS(JMAX+1)
      DMESS(JMAX+1)=DMESS(JMAX)
      DMESS(JMAX+2)=DMESS(JMAX+1)
    6 VL(JMAX+2)=1./RHO
      R(JMAX+2)=R(JMAX+1)+DMASS(JMAX+2)/RHO
      CALL GETVAR(1,2,PR(JMAX+2),VL(JMAX+2),JMAX+1,TEM(JMAX+2),C)
      CALL PEK(2,MAT(JMAX+2),TEM(JMAX+2),VL(JMAX+2),JMAX+1,0,EG(JMAX+
     1 C)
      GO TO 9
    7 CALL PET(MAT(JMAX+2),TEM(JMAX+2),VL(JMAX+2),EG(JMAX+2),JMAX+1,
    9 JHAT=JHAT+1
      JMAX=JMAX+1
      JREG(NREG)=JREG(NREG)+1
      IF(JHAT.GT.IABS(JL)-1) GO TO 3
      GO TO 1
```

```
    4 IF(R(JMAX+1) .GT. DRC) RETURN
      CALL PBOUND(TM,PR(JMAX+2))
      MAT(JMAX+2)=MAT(JMAX+1)
      DMASS(JMAX+2)=(RMAX-R(JMAX+1))*RHO
      DMESS(JMAX+1)=(DMASS(JMAX+1)+DMASS(JMAX+2))*.5
      DMESS(JMAX+2)=DMASS(JMAX+2)
      GO TO 6
    2 IF(JMAT.LE.JL) RETURN
    3 IR=1
    5 IF(JO.GT.JOM-2) GO TO 20
      IF(R(JO+3)-R(JO+1).LE.X5*R(JHAT+1))GO TO 10
    8 JO=JO+1
      GO TO 5
   10 IF(JO+1.LT.JREG(IR)) GO TO 50
      IF(JO+1.GT.JREG(IR)) GO TO 15
      IR=IR+1
      GO TO 8
   15 IR=IR+1
      GO TO 10
   20 JO=JOS
      IR=1
      IF(JO.GT.JOM-2) GO TO 999
   22 IF(R(JO+3)-R(JO+1).LE.X5*R(JHAT+1)) GO TO 25
   23 JO=JO+1
      GO TO 22
   25 IF(JO+1.LT.JREG(IR)) GO TO 50
      IF(JO+1.GT.JREG(IR)) GO TO 28
      IR=IR+1
      GO TO 23
   28 IR=IR+1
      GO TO 25
   50 J=JO
      A=DMASS(J+1) + 2.*DMESS(J+2)
      B=2.*DMESS(J+2) + DMASS(J+4)
     CC=2.*(U(J+1)*DMESS(J+1) + U(J+2)*DMESS(J+2) + U(J+3)*DMESS(J+3))
      D=2.*(U(J+1)**2*DMESS(J+1) + U(J+2)**2*DMESS(J+2) +
     1      U(J+3)**2*DMESS(J+3))
      DET=(2.*B*CC)**2-4.*(A+B)*B*(CC**2-A*D)
      IF(DET.GT.0.) GO TO 53
      IF(DET.GT.(-1.E-8)) GO TO 52
      J2=J+3
      PRINT 7001,A,B,CC,D,(DMASS(J1), DMESS(J1),U(J1),J1=J,J2)
 7001 FORMAT(17HOCZR SQRT IS NEG./(8E16.8))
      CALL EXIT
   52 DET=1.E-16
   53 U(J+2)=(2.*B*CC+ SQRT(DET))/ (2.*(A+B)*B)
      U(J+1)=(CC-B*U(J+2))/A
      EG(JO+2)=(EG(JO+3)*DMASS(JO+3) + EG(JO+2)*DMASS(JO+2))/
     1          (2.*DMESS(JO+2))
      TEM(JO+2)=(TEM(JO+3)*DMASS(JO+3) + TEM(JO+2)*DMASS(JO+2))/
```

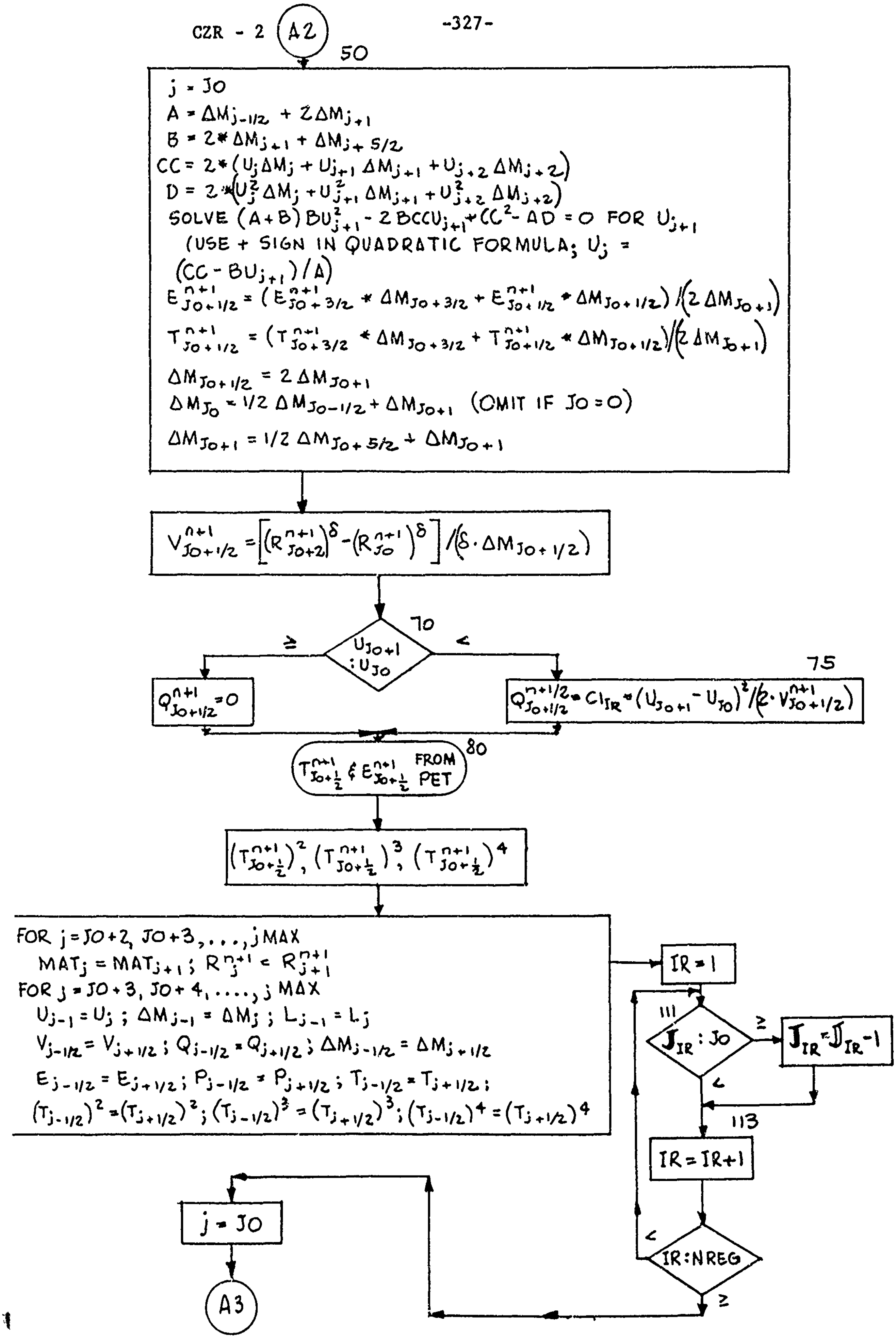
```
      1            (2.*DMESS(J0+2))
        DMASS(J0+2)=2.*DMESS(J0+2)
        IF(J0.EQ.0) GO TO 55
        DMESS(J0+1)=.5*DMASS(J0+1) + DMESS(J0+2)
   55   DMESS(J0+2)=.5*DMASS(J0+4) + DMESS(J0+2)
        IF(DELTA.LE.2) GO TO 60
        VL(J0+2)=(R(J0+3)-R(J0+1))*(R(J0+3)**2+R(J0+3)*R(J0+1) +
      1          R(J0+1)**2)/DMASS(J0+2)/3.
        GO TO 70
   60   IF(DELTA.LE.1) GO TO 65
        VL(J0+2)=(R(J0+3)-R(J0+1))*(R(J0+3)+R(J0+1))/DMASS(J0+2)/2.
        GO TO 70
   65   VL(J0+2)=(R(J0+3)-R(J0+1))/DMASS(J0+2)
   70   IF(U(J0+2).LT.U(J0+1)) GO TO 75
        Q(J0+2)=0.
        GO TO 80
   75   Q(J0+2)=C1(IR)*(U(J0+2)-U(J0+1))**2/(2.*VL(J0+2))
   80   CALL PET(MAT(J0+2),TEM(J0+2),VL(J0+2),PR(J0+2),EG(J0+2),J0+1,C
        TEMSQ(J0+2)=TEM(J0+2)**2
        TEM3(J0+2)=TEM(J0+2)*TEMSQ(J0+2)
        TEM4(J0+2)=TEMSQ(J0+2)**2
        J1=J0+2
        DO 100 J=J1,JMAX
       MAT(J)=MAT(J+1)
  100   R(J)=R(J+1)
        J1=J0+3
        DO 110 J=J1,JMAX
        U(J)=U(J+1)
        DMESS(J)=DMESS(J+1)
        EL(J)=EL(J+1)
        VL(J)=VL(J+1)
       VLM(J) = VLM(J+1)
        Q(J)=Q(J+1)
        DMASS(J)=DMASS(J+1)
        EG(J)=EG(J+1)
       EGM(J) = EGM(J+1)
        PR(J)=PR(J+1)
        PRM(J) = PRM(J+1)
        TEM(J)=TEM(J+1)
        TEMSQ(J)=TEMSQ(J+1)
        TEM3(J)=TEM3(J+1)
  110   TEM4(J)=TEM4(J+1)
       IF (NREG.EQ.1) GO TO 115
       IR=1
  111  IF (JREG(IR).LT.J0) GO TO 113
       JREG(IR)=JREG(IR)-1
  113  IR=IR+1
       IF (IR.LT.NREG) GO TO 111
  115   J=J0
        IF(IRAD.EQ.1) GO TO 124
  120   IF(J0.EQ.0) GO TO 122
```

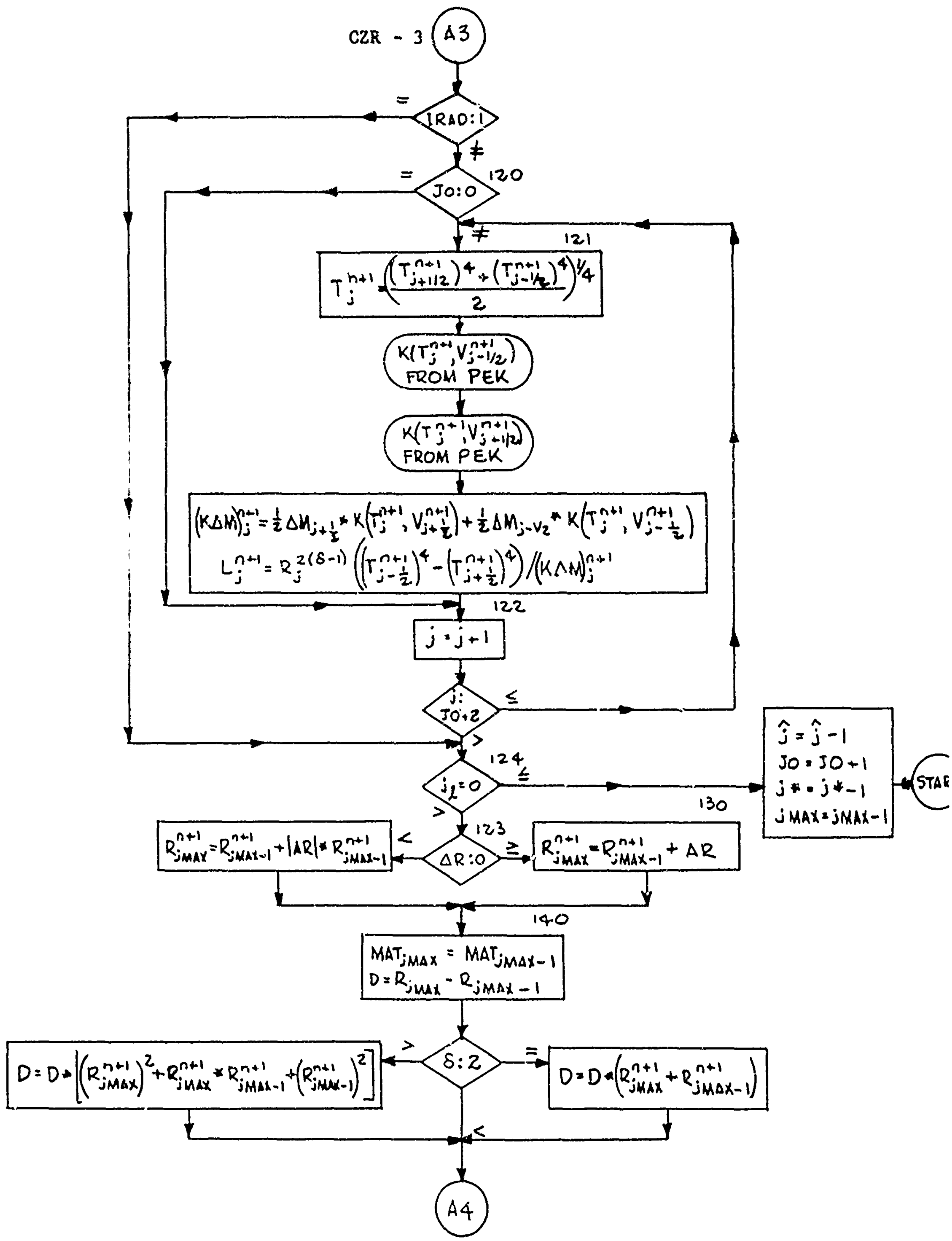
```
 121  TAM(J+1)=((TEM4(J+1)+TEM4(J+2))/2.)**.25
      CALL PEK(3,MAT(J+1),TAM(J+1),VL(J+1),J,0,KM(J+1),C)
      CALL PEK(3,MAT(J+2),TAM(J+1),VL(J+2),J,0,KP(J+1),C)
      KDM(J+1)=.5*DMASS(J+1)*KM(J+1) + .5*DMASS(J+2)*KP(J+1)
      EL(J+1)= R(J+1)**(2*(DELTA-1))*(TEM4(J+1)-TEM4(J+2))/KDM(J+1)
 122  J=J+1
      IF(J.LE.J0+2) GO TO 121
 124  IF(JL.GT.0) GO TO 123
      JHAT=JHAT-1
      J0=J0+1
      JSTAR=JSTAR-1
      JMAX=JMAX-1
      GO TO 1
 123  IF(DRC.GE.0.) GO TO 130
      R(JMAX+1)=R(JMAX)+ABS(DRC)*R(JMAX)
      GO TO 140
 130  R(JMAX+1)=R(JMAX)+DRC
 140  MAT(JMAX+1)=MAT(JMAX)
     DELT=DELTA
     D=R(JMAX+1)-R(JMAX)
     IF(DELTA.LE.2)GO TO 150
     D=D*(R(JMAX+1)**2+R(JMAX+1)*R(JMAX)+R(JMAX)**2)
     GO TO 156
 150 IF (DELTA.LE.1) GO TO 156
     D=D*(R(JMAX+1)+R(JMAX))
156   IF (EO(IR).NE.0.) GO TO 160
      CALL RBOUND(TM,RHO)
      VL(JMAX+1)= 1./RHO
     CALL PET(MAT(JMAX+1),TEM(JMAX+1),VL(JMAX+1),PR(JMAX+1),EG(JMAX+1),
    1 JMAX,C)
 160 DMASS(JMAX+1)=D/DELT/VL(JMAX+1)
      IF (EO(IR).GT.0.) GO TO 162
      EZ=EG(JMAX+1)
     EGM(JMAX+1) = EG(JMAX+1)
     PRM(JMAX+1) = PR(JMAX+1)
     VLM(JMAX+1) = VL(JMAX+1)
      GO TO 164
162   EZ=EO(IR)
164   SUM2(NREG)=SUM2(NREG)+EZ*DMASS(JMAX+1)
     DMESS(JMAX)=(DMASS(JMAX)+DMASS(JMAX+1))/2.
     IF(J0+1.LT.JSTAR) GO TO 170
     IF(J0+1.GT.JSTAR) GO TO 180
     IF(TEM(J0+2).LT.Z1) GO TO 170
     GO TO 180
 170 JSTAR=JSTAR-1
 180 JHAT=JHAT-1
     J0=J0+1
      GO TO 2
 999  PRINT 7000
7000 FORMAT(26HONO MORE ZONES TO COMBINE.  )
      CALL EXIT
     END
```

CZR - 1

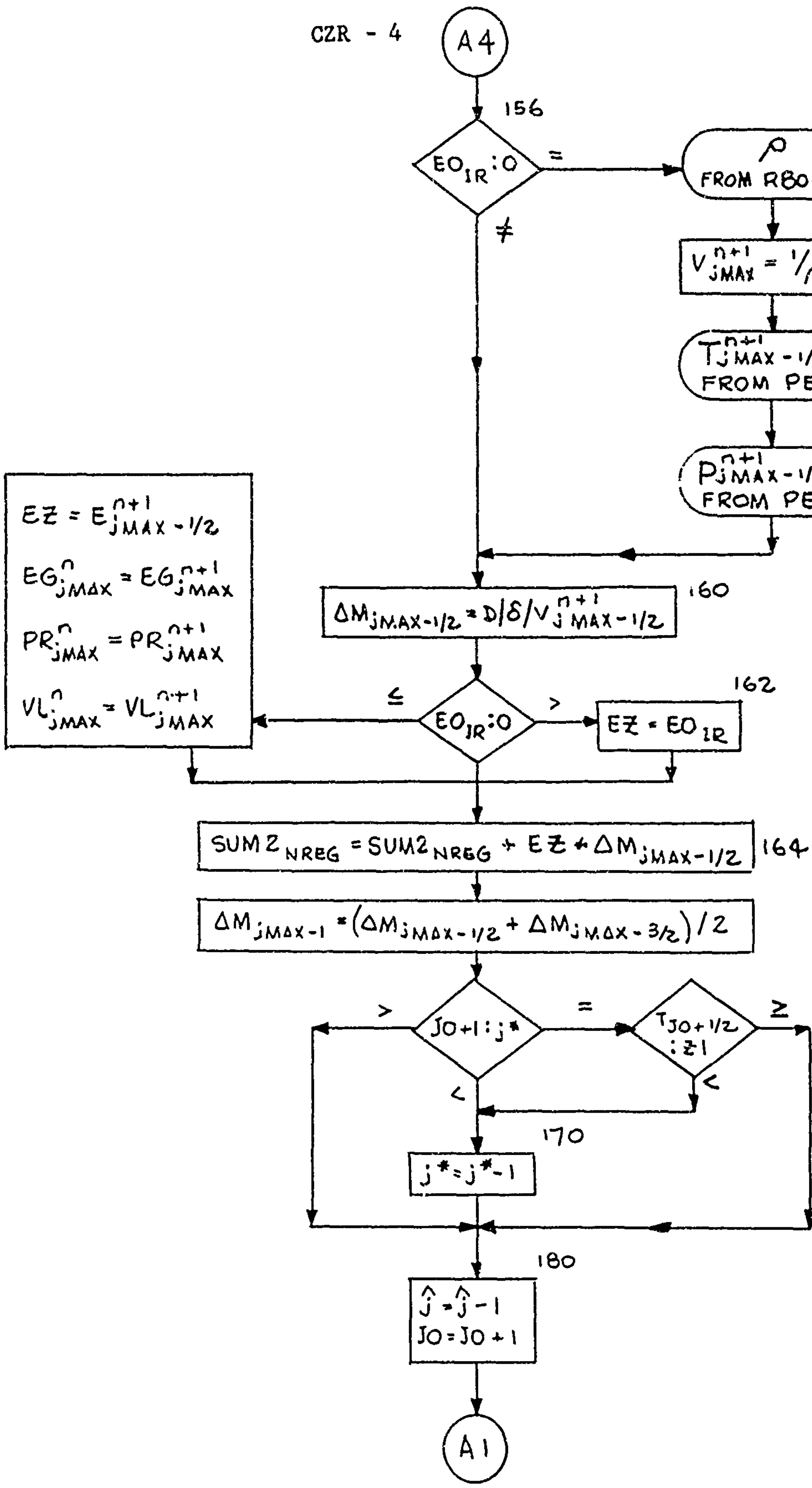

START
JL:O
RET
ρ FROM RBOUND
Rjmax:ΔR
RET
Pjmax+1/2 FROM PBOUND
Rojmax - Rn+1jmax : ΔMjmax-1/2/ρ
Pjmax+1/2 FROM PBOUND
MATjmax+1/2 = MATjmax-1/2
ΔMjmax+1/2 = ΔMjmax-1/2
ΔMjmax = ΔMjmax-1
ΔMjmax+1 = ΔMjmax
MATjmax+1/2 = MATjmax-1/2
ΔMjmax+1/2 = (Rojmax - Rn+1jmax)*ρ
ΔMjmax = (ΔMjmax+1/2 + ΔMjmax-1/2)/2
ΔMjmax+1 = ΔMjmax+1/2
Vjmax+1/2 = 1/ρ
Rjmax+1 = Rjmax + ΔMjmax-1/2/ρ
A1
Tjmax+1/2 FROM GETVAR
RET
ĵ : jl
Ejmax+1/2 FROM PEK
ĵ = ĵ + 1
jmax = jmax + 1
JNREG = JNREG + 1
ĵ : |jl| - 1
IR = 1
JO = JO + 1
RJO+2 - RJO : x3 Rĵ
JO : JOM-2
JO = JOS
IR = 1
JO : JOM-2
WRITE MESSAGE
EXIT
IR = IR + 1
JO+1 : JIR
IR = IR + 1
JO = JO + 1
RJO+2 - RJO : x3 Rĵ
IR = IR + 1
JO+1 : JIR
IR = IR + 1
A2

CZR - 2


A2
50
$j = JO$
$A = \Delta M_{j-1/2} + 2\Delta M_{j+1}$
$B = 2 * \Delta M_{j+1} + \Delta M_{j+5/2}$
$CC = 2 * (U_j \Delta M_j + U_{j+1} \Delta M_{j+1} + U_{j+2} \Delta M_{j+2})$
$D = 2 * (U_j^2 \Delta M_j + U_{j+1}^2 \Delta M_{j+1} + U_{j+2}^2 \Delta M_{j+2})$
SOLVE $(A+B) BU_{j+1}^2 - 2BCCU_{j+1} + CC^2 - AD = 0$ FOR U_{j+1}
(USE + SIGN IN QUADRATIC FORMULA; $U_j = (CC - BU_{j+1})/A$)
$E^{n+1}_{JO+1/2} = (E^{n+1}_{JO+3/2} * \Delta M_{JO+3/2} + E^{n+1}_{JO+1/2} * \Delta M_{JO+1/2}) / (2 \Delta M_{JO+1})$
$T^{n+1}_{JO+1/2} = (T^{n+1}_{JO+3/2} * \Delta M_{JO+3/2} + T^{n+1}_{JO+1/2} * \Delta M_{JO+1/2}) / (2 \Delta M_{JO+1})$
$\Delta M_{JO+1/2} = 2 \Delta M_{JO+1}$
$\Delta M_{JO} = 1/2 \Delta M_{JO-1/2} + \Delta M_{JO+1}$ (OMIT IF $JO = 0$)
$\Delta M_{JO+1} = 1/2 \Delta M_{JO+5/2} + \Delta M_{JO+1}$
$V^{n+1}_{JO+1/2} = \left[(R^{n+1}_{JO+2})^\delta - (R^{n+1}_{JO})^\delta\right] / (\delta \cdot \Delta M_{JO+1/2})$
70
$U_{JO+1} : U_{JO}$
$\geq$
$<$
$Q^{n+1}_{JO+1/2} = 0$
75
$Q^{n+1/2}_{JO+1/2} = Cl_{IR} * (U_{JO+1} - U_{JO})^2 / (2 \cdot V^{n+1}_{JO+1/2})$
80
$T^{n+1}_{JO+\frac{1}{2}}$ & $E^{n+1}_{JO+\frac{1}{2}}$ FROM PET
$(T^{n+1}_{JO+\frac{1}{2}})^2, (T^{n+1}_{JO+\frac{1}{2}})^3, (T^{n+1}_{JO+\frac{1}{2}})^4$
FOR $j = JO+2, JO+3, \ldots, jMAX$
$MAT_j = MAT_{j+1}$; $R^{n+1}_j = R^{n+1}_{j+1}$
FOR $j = JO+3, JO+4, \ldots, jMAX$
$U_{j-1} = U_j$; $\Delta M_{j-1} = \Delta M_j$; $L_{j-1} = L_j$
$V_{j-1/2} = V_{j+1/2}$; $Q_{j-1/2} = Q_{j+1/2}$; $\Delta M_{j-1/2} = \Delta M_{j+1/2}$
$E_{j-1/2} = E_{j+1/2}$; $P_{j-1/2} = P_{j+1/2}$; $T_{j-1/2} = T_{j+1/2}$;
$(T_{j-1/2})^2 = (T_{j+1/2})^2$; $(T_{j-1/2})^3 = (T_{j+1/2})^3$; $(T_{j-1/2})^4 = (T_{j+1/2})^4$
$IR = 1$
111
$J_{IR} : JO$
$\geq$
$J_{IR} = J_{IR} - 1$
$<$
113
$IR = IR + 1$
$IR : NREG$
$<$
$\geq$
$j = JO$
A3


CZR - 3
A3
IRAD:1
120
JO:0
121
FROM PEK
FROM PEK
122
j = j+1
124
123
ΔR:0
130
140
δ:2
A4
STAR

CZR - 4

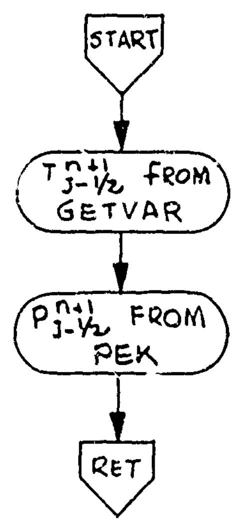

A4
156
EO_IR : 0
=
≠
ρ FROM RBOUND
V^{n+1}_{jMAX} = 1/ρ
T^{n+1}_{jMAX-1/2} FROM PET
P^{n+1}_{jMAX-1/2} FROM PET
160
ΔM_{jMAX-1/2} = D/δ/V^{n+1}_{jMAX-1/2}
162
EO_JR : 0
≤
>
EZ = E^{n+1}_{jMAX-1/2}
EG^n_{jMAX} = EG^{n+1}_{jMAX}
PR^n_{jMAX} = PR^{n+1}_{jMAX}
VL^n_{jMAX} = VL^{n+1}_{jMAX}
EZ = EO_IR
164
SUM2_NREG = SUM2_NREG + EZ * ΔM_{jMAX-1/2}
ΔM_{jMAX-1} = (ΔM_{jMAX-1/2} + ΔM_{jMAX-3/2})/2
JO+1 : j*
>
=
<
T_{JO+1/2} : Z1
≥
<
170
j* = j* - 1
180
ĵ = ĵ - 1
JO = JO + 1
A1

34. PET(MAT,T,V,P,E,J,C)

PET is introduced to make possible the use of analytic equations of state that are not functions of T and V, since in non-radiative problems it is often more convenient to use P(E,V) and ignore T. Normally GETVAR is called to obtain T from E and V through the function E(T,V), then PEK is called to get P(T,V). In this case the equations of state are included in the FP100x and FE100x form. If the analytic equation of state is written as P(E,V), PET will be the equation of state subroutine, calculating P from E and V. In this case PET may also calculate T(E,V) if desired, although this is not necessary unless $\hat{J}$ is determined according to a temperature criterion. If the equations of state are in the normal form, i.e., P(T,V), E(T,V), the deck $IBFTC STNDPT must be present as well as the FP100x and FE100x (FK100x, if necessary). If the special form is used and PET is used to calculate P and T the FP100x and FE100x are, of course, not necessary in the Executor.

```
$IBFTC STNDPT
       SUBROUTINE PET(MAT,T,V,P,E,J,C)
       DIMENSION C(1)
       CALL GETVAR(2,2,E,V,J,T,C)
       CALL PEK(1,MAT,T,V,J,0,P,C)
       RETURN
       END
```

PET



35. PBOUND(T,P) and RBOUND(T,R)

PBOUND and RBOUND are called by CZR. They specify P(t) and R(t), the pressure and density as a function of time, of the zones to be added. These are only called if the adding and combining of zones is of the sort which attempts to maintain a constant R_{jmax}.

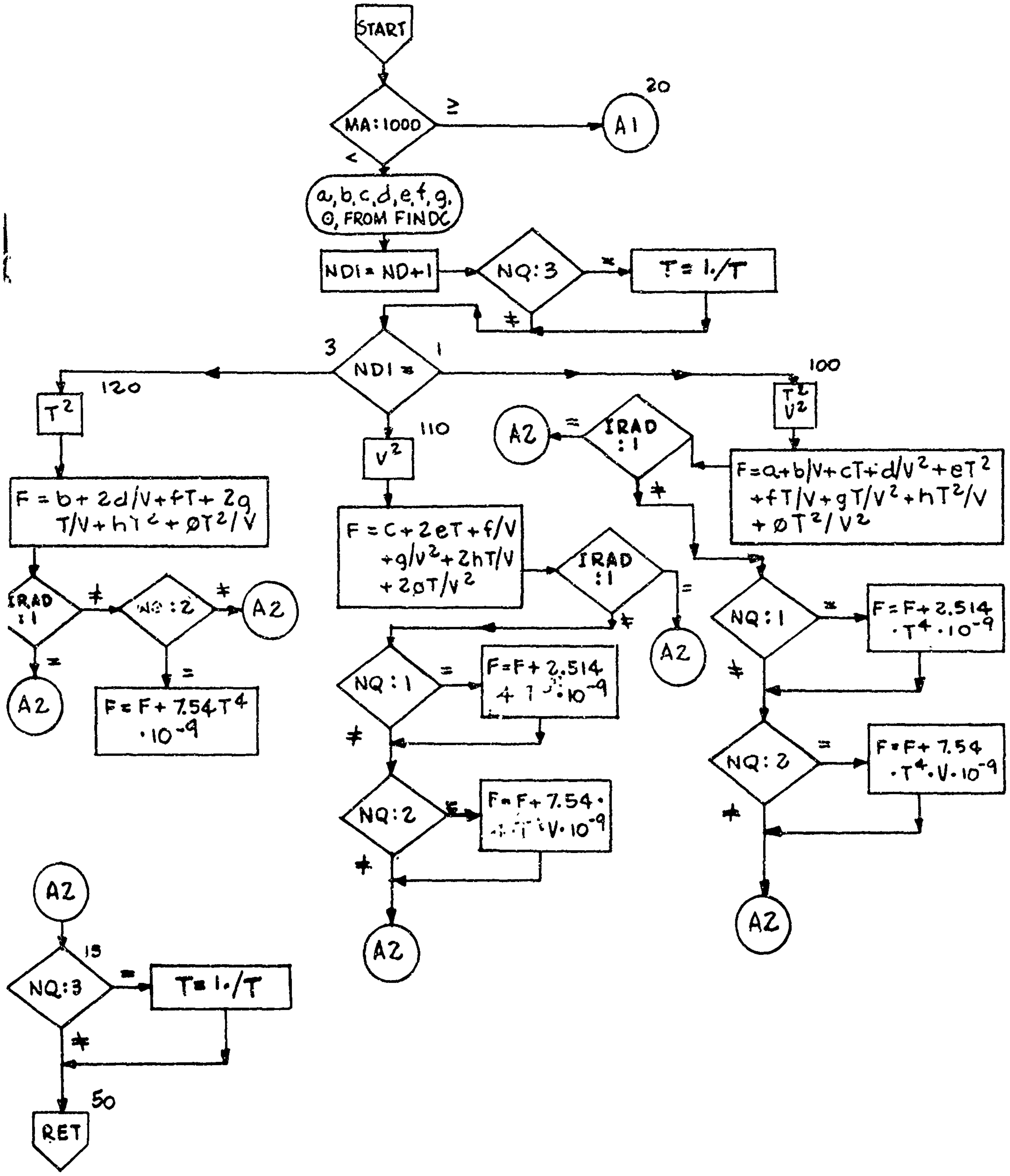
36. PEK

See Section V paragraph 18.

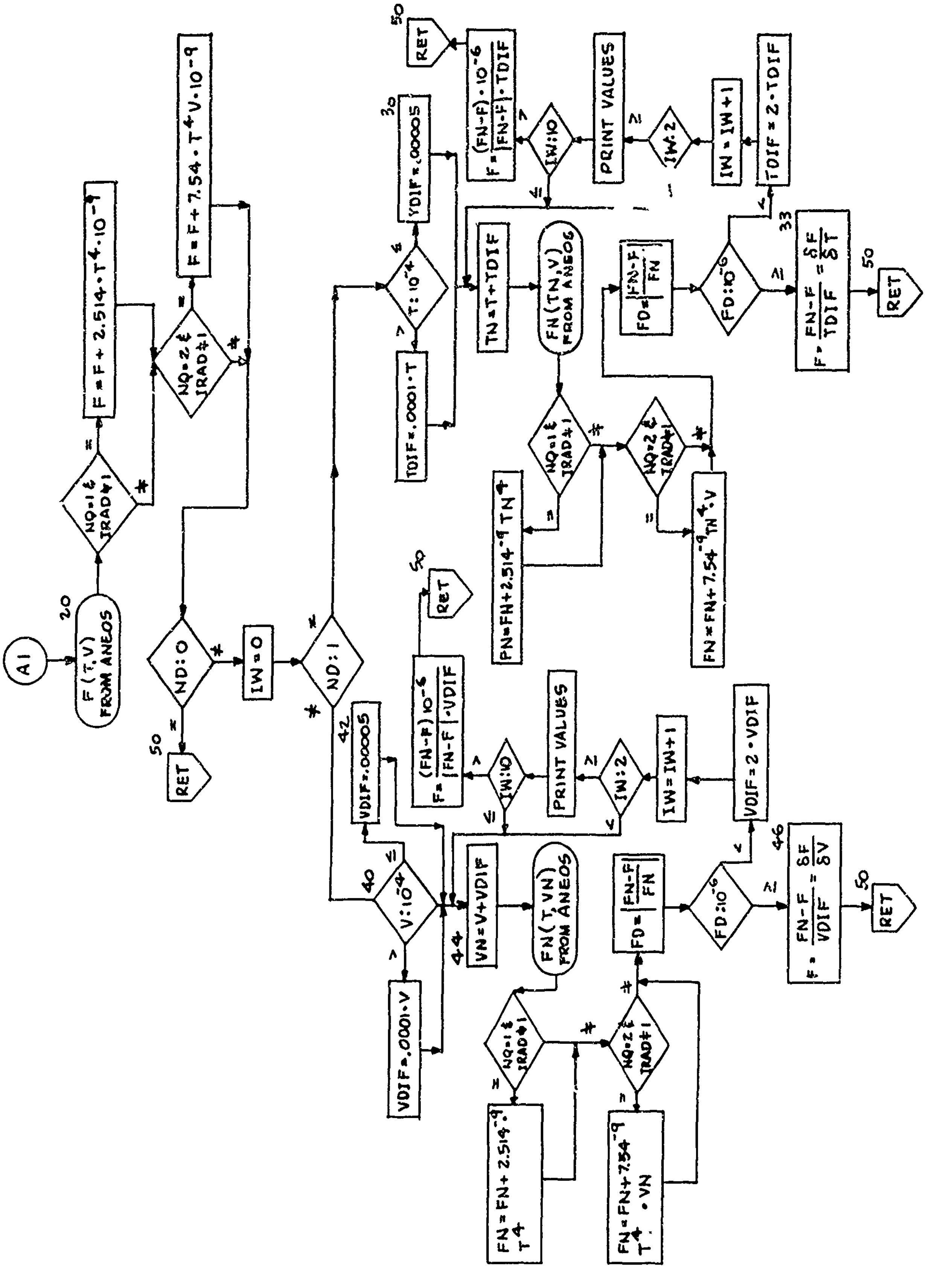
```
$IBFTC PEKF
      SUBROUTINE PEK(NQ,MA,TP,VP,J,ND,F,C)
C     COMMON CARD  LABELED /IKA2/ GROUP TO BE PLACED HERE
       DIMENSION COE(9)
      DIMENSION C(1)
      IF (MA.GE.1000) GO TO 20
      CALL FINDC(NQ,MA,TP,VP,COE,C)
      ND1=ND+1
C
C     TRANSFER TO FIND FUNCTION, DERIV W.R.T. T OR DERIV W.R.T. V RESPT
C
       IF (NQ.EQ.3) TP=1./TP
       GO TO (100,110,120),ND1
 100   T2= TP*TP
      V2=VP*VP
       F=COE(1)+COE(2)/VP+COE(3)*TP+COE(4)/V2+COE(5)*T2+COE(6)*TP/VP+
     1 COE(7)*TP/V2+COE(8)*T2/VP+COE(9)*T2/V2
       IF (IRAD.EQ.1) GO TO 15
       IF(NQ.EQ.1) F=F+2.514*TP**4*1.E-9
       IF(NQ.EQ.2) F=F+7.54*TP**4*VP*1.E-9
       GO TO 15
  110 V2=VP*VP
       F=COE(3)+COE(5)*2.*TP+COE(6)/VP+COE(7)/V2+COE(8)*2.*TP/VP+
     1 COE(9)*2.*TP/V2
       IF (IRAD.EQ.1) GO TO 15
       IF(NQ.EQ.1) F=F+2.514*TP**3*4.E-9
       IF(NQ.EQ.2) F=F+7.54*TP**3*VP*4.E-9
       GO TO 15
  120 T2=TP*TP
       F= COE(2)+COE(4)*2./VP+COE(6)*TP+COE(7)*2.*TP/VP+COE(8)*T2+
     1 COE(9)*2.*T2/VP
       IF (IRAD.EQ.1) GO TO 15
       IF(NQ.EQ.2) F=F+7.54*TP**4*1.E-9
 15    IF (NQ.EQ.3) TP= 1./TP
      GO TO 50
```

```
1005 FORMAT (1H0,28H *** ERROR IN PEK--ND WRONG.)
  20 CALL ANEOS (NQ,MA,TP,VP,F)
     IF (NQ.EQ.1.AND.IRAD.NE.1) F=F+2.514E-9*TP**4
     IF (NQ.EQ.2.AND.IRAD.NE.1) F=F+7.54E-9*TP**4*VP
     IF (ND.EQ.0) GO TO 50
      IW=0
     IF (ND.NE.1) GO TO 40
     IF (TP.LE.0.0001 ) GO TO 30
     TDIF=TP*.0001
     GO TO 32
  30 TDIF=.00005
  32 TN=TP+TDIF
     CALL ANEOS (NQ,MA,TN,VP,FN)
     IF (NQ.EQ.1.AND.IRAD.NE.1) FN=FN+2.514E-9*TN**4
     IF (NQ.EQ.2.AND.IRAD.NE.1) FN=FN+7.54E-9*TN**4*VP
     FD=ABS((FN-F)/FN)
     IF (FD.GE.1.E-06) GO TO 33
     TDIF=2.*TDIF
      IW=IW+1
      IF(IW.LT.2) GO TO 32
      PRINT 2000, J,NQ,ND,IW,TP,TDIF,TN,F,FN,FD
2000  FORMAT (4I6,6E16.8)
      IF (IW.LE.10) GO TO 32
      F=(FN-F)*1.E-06/ABS(FN-F)/TDIF
      GO TO 50
33   F= (FN-F)/TDIF
     GO TO 50
  40 IF (VP.LE.0.0001 ) GO TO 42
     VDIF=VP*.0001
     GO TO 44
  42 VDIF=.00005
  44 VN=VP+VDIF
     CALL ANEOS (NQ,MA,TP,VN,FN)
     IF (NQ.EQ.1.AND.IRAD.NE.1) FN=FN+2.514E-9*TP**4
     IF (NQ.EQ.2.AND.IRAD.NE.1) FN=FN+7.54E-9*TP**4*VN
     FD=ABS((FN-F)/FN)
     IF (FD.GE.1.E-06) GO TO 46
     VDIF=2.*VDIF
      IW=IW+1
      IF (IW.LT.2) GO TO 44
      PRINT 2000,J,NQ,ND,IW,TP,VDIF,VN,F,FN,FD
      IF (IW.LE.10) GO TO 44
      F=(FN-F)*1.E-06/ABS(FN-F)/VDIF
      GO TO 50
46   F = (FN-F)/VDIF
  50 RETURN
     END
```

PEK - 1


START
MA:1000
≥
<
20
A1
a, b, c, d, e, f, g, ⊘, FROM FINDC
NDI = ND+1
NQ:3
=
≠
T = 1./T
NDI =
3
1
120
110
100
T^2
V^2
T^2 V^2
F = b + 2d/V + fT + 2g T/V + hT² + ⊘T²/V
F = c + 2eT + f/V + g/V² + 2hT/V + 2⊘T/V²
F = a + b/V + cT + d/V² + eT² + fT/V + gT/V² + hT²/V + ⊘T²/V²
IRAD :1
NQ:2
NQ:1
F = F + 7.54T⁴ · 10⁻⁹
F = F + 2.514 · T⁴ · 10⁻⁹
F = F + 7.54 · T⁴ · V · 10⁻⁹
A2
15
T = 1./T
50
RET

PEK-2


A1
F(T,V) FROM ANEOS
NO=1 & IRAD≠1
F = F + 2.514 · T⁴ · 10⁻⁹
NO=2 & IRAD≠1
F = F + 7.54 · T⁴ V · 10⁻⁹
ND:0
RET
IW=0
ND:1
T:10⁻⁴
TDIF=.0001·T
TDIF=.00005
TN=T+TDIF
FN(TN,V) FROM ANEOS
FN=FN+2.514⁻⁹ TN⁴
FN=FN+7.54⁻⁹ TN⁴·V
FD=|FN-F / FN|
FD:10⁻⁶
F = FN-F / TDIF = δF/δT
TDIF = 2·TDIF
IW = IW+1
IW:2
PRINT VALUES
IW:10
F = (FN-F)·10⁻⁶ / |FN-F| · TDIF
V:10⁻⁴
VDIF=.0001·V
VDIF=.00005
VN=V+VDIF
FN(T,VN) FROM ANEOS
FN=FN+2.514⁻⁹ T⁴
FN=FN+7.54⁻⁹ T⁴·VN
FD=|FN-F / FN|
F = FN-F / VDIF = δF/δV
VDIF=2·VDIF
F = (FN-F) 10⁻⁶ / |FN-F| · VDIF

37. FINDC

See Section V paragraph 19.

```
$IBFTC FINDC   REF
      SUBROUTINE FINDC (NF,MA,TP,VP,F,C)
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
       DIMENSION F(9), C(1)
      MA1=MA+1
      LOOK = IDEOS(MA1)
      IF(LOOK.NE. 0)  GO TO 5
    2 PRINT 7001,MA
 7001 FORMAT (19H1    MATERIAL NO. =I4,25H IS NOT USED IN THIS JOB.)
      RETURN
    5 DO 6 I=1,6
      IF(IORDER(I).EQ.LOOK) GO TO 9
    6 CONTINUE
       GO TO 2
    9 MA1 =I
      ITABT=0
      L1= IBEGT(NF,MA1)
      L2= IBEGV(NF,MA1)-1
       IF(NF.EQ.3) TP= 1./TP
      DO 7 I=L1,L2,2
       IF((TP.GE.C(I).AND.TP.LE.C(I+2)).OR.(TP.LE.C(I).AND.TP.GE.C(I+2))
     1 ) GO TO 10
      ITABT= ITABT+1
    7 CONTINUE
 10    IF(NF.EQ.3) TP= 1./TP
       ITABV=0
      L1= IBEGV(NF,MA1)
      L2= IBEGC(NF ,MA1)-1
       VP=1./VP
      DO 13 I=L1,L2,2
       IF((VP.GE.C(I).AND.VP.LE.C(I+2)).OR.(VP.LE.C(I).AND.VP.GE.C(I+2))
     1 ) GO TO 15
      ITABV=ITABV+1
   13 CONTINUE
   15 NOFT = (IBEGV(NF,MA1)-IBEGT(NF,MA1))/2
      ICSUB = IBEGC(NF,MA1)+ ITABV*NOFT*9+ITABT*9-1
      DO 20 I=1,9
      ISUB =ICSUB+I
   20 F(I)= C(ISUB)
       VP=1./VP
      RETURN
      END
```

38. ANEOS

See Section V paragraph 20.

```
$IBFTC ANEOS   REF
      SUBROUTINE ANEOS (NF,MA,TP,VP,F)
   10 LA=MA-999
      IF (NF.NE.1) GO TO 20
      GO TO (11,12,13,14,15,16),LA
   11 F =  FP1000 (TP,VP)
      GO TO 40
   12 F=   FP1001 (TP,VP)
      GO TO 40
   13 F =  FP1002  (TP,VP)
      GO TO 40
   14 F =  FP1003 (TP,VP)
      GO TO 40
   15 F =  FP1004 (TP,VP)
      GO TO 40
   16 F =  FP1005 (TP,VP)
      GO TO 40
   20 IF (NF.NE.2) GO TO 30
      GO TO (21,22,23,24,25,26),LA
   21 F = FE1000(TP,VP)
      GO TO 40
   22 F= FE1001(TP,VP)
      GO TO 40
   23 F= FE1002 (TP,VP)
      GO TO 40
   24 F = FE1003 (TP,VP)
      GO TO 40
   25 F = FE1004 (TP,VP)
      GO  TO 40
   26 F = FE1005 (TP,VP)
      GO TO 40
   30 GO TO (31,32,33,34,35,36),LA
   31 F =FK1000(TP,VP)
      GO TO 40
   32 F= FK1001(TP,VP)
      GO TO 40
   33 F = FK1002(TP,VP)
      GO TO 40
   34 F= FK1003(TP,VP)
      GO TO 40
   35 F = FK1004 (TP,VP)
      GO TO 40
   36 F = FK1005 (TP,VP)
   40 RETURN
      END
```

39. FP100x, FE100x, FK100x

See Section V paragraph 21, 22 and 23.

40. GETVAR

See Section V paragraph 24.

```
$IBFTC GTVARE
      SUBROUTINE GETVAR (MF,NV,F,VAR,JV,OVAR,C)
C     COMMON CARDS LABELED  /IKA2/ AND /IKA2B/ GROUPS TO BE PLACED HERE
       INTEGER  DELTA, REGNC, UNCGS, UNMKS
       REAL  KMIN, KMAX, KP, KM, KDM
C     SEE TABLE FOR OTHER SINGLY LABELED COMMON CARDS TO BE PLACED HERE
      DIMENSION C(1)
      IF(MAT(JV+1).GE.1000) GO TO 1
      CALL GTVRTB(MF,NV,F,VAR,JV,OVAR,MAT(JV+1),C)
      RETURN
    1 NCOT=0
      IF (NV.EQ.2) GO TO 40
   30 OVARP=VL(JV+1)
      GO TO 50
   40 OVARP=TEM(JV+1)
      GO TO 60
   50 CALL PEK (MF,MAT(JV+1),VAR,OVARP,JV,0,FN,C)
      CALL PEK (MF,MAT(JV+1),VAR,OVARP,JV,2,FP,C)
      GO TO 70
   60 CALL PEK (MF,MAT(JV+1),OVARP,VAR,JV,0,FN,C)
      CALL PEK (MF,MAT(JV+1),OVARP,VAR,JV,1,FP,C)
   70 IF (ABS(FP).GT.X4*ABS(FN)) GO TO 80
      FP = (FP/ABS(FP))*X4*ABS(FN)
   80 OVAR=OVARP+(F-FN)/FP
      D=ABS((OVAR-OVARP)/OVAR)
      IF (D.LE.X4.OR.ABS((F-FN)/F).LE.X4) RETURN
      NCOT=NCOT+1
      IF (NCOT.LE.10) GO TO 85
   81  WRITE (6,1010) JV, NCOT, OVAR, F,FN,VAR,MF,NV
 1010  FORMAT(1H0,5H   JV=I2,3X,5HNCOT=I2,3X,5HOVAR=E14.6,3X,2HF=E14.6,
     1  3X,3HFN=E14.6,3X,4HVAR=E14.6,3X,3HMF=I2,3X,3HNV=I2)
      IF (NCOT.LE.15) GO TO 85
       IF (NCOT.GT.16) GO TO 83
       OVARP = (OVAR+OVARP)/2.
       GO TO 90
   83  IF (NCOT.LE.21) GO TO 85
       CALL EXIT
 85   OVARP=OVAR
   90  IF (NV.EQ.2) GO TO 60
       GO TO 50
      END
```

41. GTVRTB

GTVRTB is similar to the GTVRTB of the Generator section of HAROLD. The difference is that in the Executor portion, GTVRTB keeps track of the macro box in which the solution was previously found for each material and function, thus reducing the number of function values calculated.

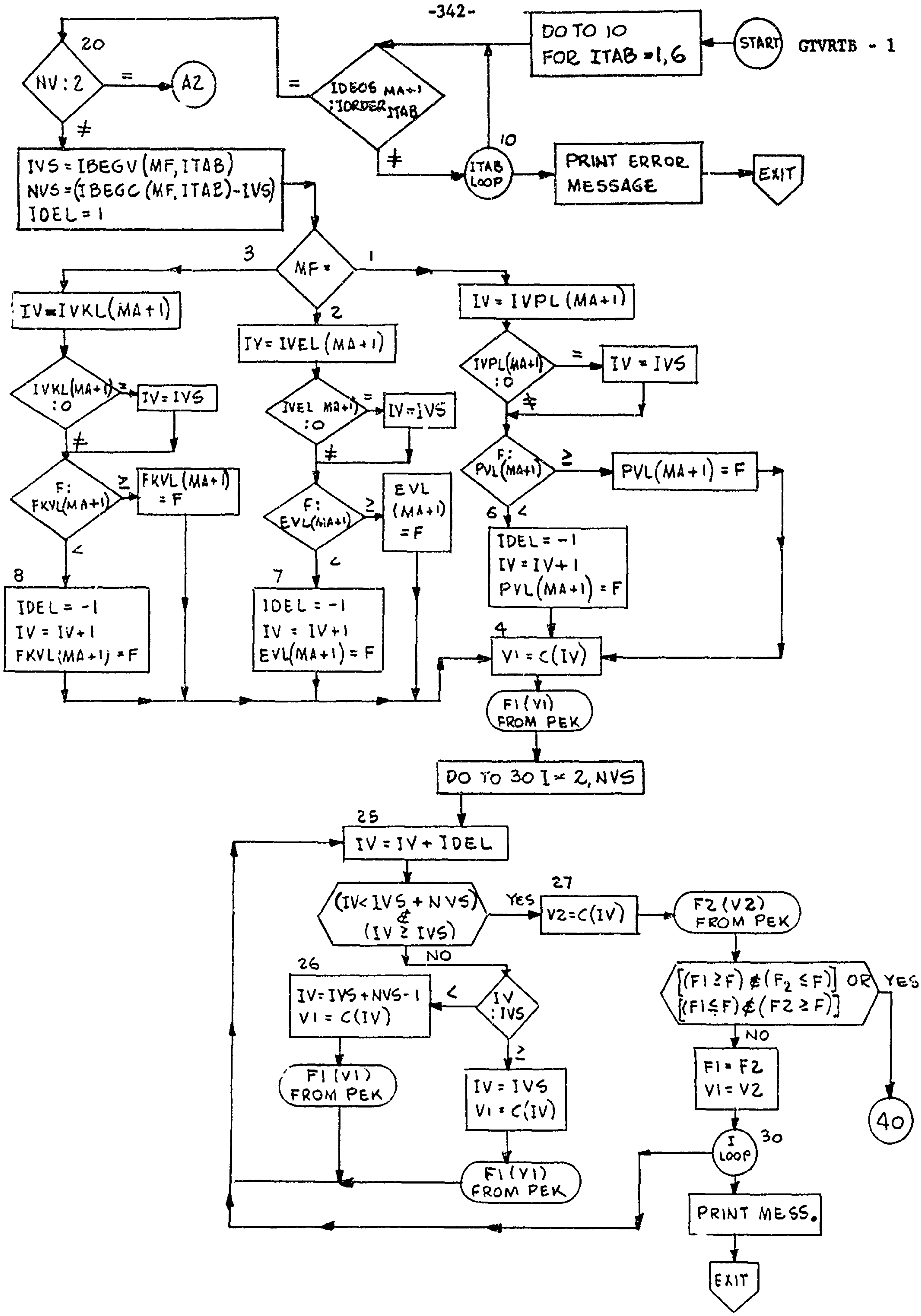
```
$IBFTC GVRTBE
      SUBROUTINE GTVRTB(MF,NV,F,VAR,JV,OVAR,MA,C)
C     COMMON CARD  LABELED /IKA2/ GROUP TO BE PLACED HERE
      COMMON /EOSCOM/ MEOS, IDEOS(6), IORDER(6), IBEGT(3,6), DUM,
     1 IBEGV(3,6), IBEGC(3,6)
      DIMENSION IVPL(6),IVEL(6),IVKL(6),ITPL(6),ITEL(6),ITKL(6)
     1, PVL(6), EVL(6), FKVL(6), ETL(6), PTL(6), FKTL(6)
      DIMENSION C(1)
      DO 10 ITAB=1,6
      IF(IDEOS(MA+1).EQ.IORDER(ITAB)) GO TO 20
   10 CONTINUE
      PRINT 7000
 7000 FORMAT(16H0ILLEGAL EOS NO.)
      CALL EXIT
   20 IF(NV.EQ.2) GO TO 100
      IVS=IBEGV(MF,ITAB)
      NVS=IBEGC(MF,ITAB)-IVS
      IDEL=1
      GOTO (1,2,3),MF
    1 IV=IVPL(MA+1)
      IF(IVPL(MA+1).EQ.0) IV=IVS
      IF(F.LT.PVL(MA+1)) GO TO 6
      PVL(MA+1)=F
      GO TO 4
    6 IDEL=-1
      IV=IV+1
      PVL(MA+1)=F
      GO TO 4
    2 IV=IVEL(MA+1)
      IF(IVEL(MA+1).EQ.0) IV=IVS
      IF(F.LT.EVL(MA+1))  GO TO 7
      EVL(MA+1)=F
      GO TO 4
    7 IDEL=-1
      IV=IV+1
      EVL(MA+1)=F
      GO TO 4
    3 IV=IVKL(MA+1)
      IF(IVKL(MA+1).EQ.0) IV=IVS
      IF(F.LT.FKVL(MA+1)) GO TO 8
      FKVL(MA+1)=F
      GO TO 4
```

```
    8  IDEL=-1
       IV=IV+1
       FKVL(MA+1)=F
    4  V1=C(IV)
       CALL PEK(MF,MA,VAR,V1,JV,0,F1,C)
       DO 30 I=2,NVS
   25  IV=IV+IDEL
       IF(IV.LT.IVS+NVS.AND.IV.GE.IVS) GO TO 27
       IF(IV.LT.IVS) GO TO 26
       IV=IVS
       V1=C(IV)
       CALL PEK(MF,MA,VAR,V1,JV,0,F1,C)
       GO TO 25
   26  IV=IVS+NVS-1
       V1=C(IV)
       CALL PEK(MF,MA,VAR,V1,JV,0,F1,C)
       GO TO 25
   27  V2=C(IV)
       CALL PEK(MF,MA,VAR,V2,JV,0,F2,C)
       IF(((F1.GE.F).AND.(F2.LE.F)).OR.((F1.LE.F).AND.(F2.GE.F)))GOTO40
       F1=F2
       V1=V2
   30  CONTINUE
       PRINT 7001
 7001  FORMAT(38HOGTVRTB UNABLE TO SPAN FUNCTION VALUE.)
       CALL EXIT
   40  NCOT=0
       GO TO (41,42,43),MF
   41  IF (IDEL.EQ.1) IVEL(MA+1)=IV-1
       IF (IDEL.EQ.-1)IVEL(MA+1)=IV
       GO TO 44
   42  IF(IDEL.EQ. 1) IVPL(MA+1)=IV-'
       IF(IDEL.EQ.-1) IVPL(MA+1)=IV
       GO TO 44
   43  IF(IDEL.EQ. 1) IVKL(MA+1)=IV-1
       IF(IDEL.EQ.-1) IVKL(MA+1)=IV
   44  VL=V2
   60  V3=V1-(V1-V2)*(F1-F)/(F1-F2)
      IF (ABS((VL-V3)/V3).GT.X4) GO TO 70
       OVAR=V3
       RETURN
   70  NCOT=NCOT+1
       IF(NCOT.LE.15) GO TO 80
       IF(NCOT.GT.20) CALL EXIT
       PRINT 7002, V1,V2,V3,F1,F2,F3  ,MA,JV,VAR
 7002  FORMAT(23HOV1, V2, V3, F1, F2, F3/6E16.7 /2I12,E16.7)
   80  CALL PEK(MF,MA,VAR,V3,JV,0,F3,C)
       VL=V3
       IF(F3.GT.F) GO TO 90
   85  F1=F3
       V1=V3
       GO TO 60
   90  F2=F3
       V2=V3
       GO TO 60
```

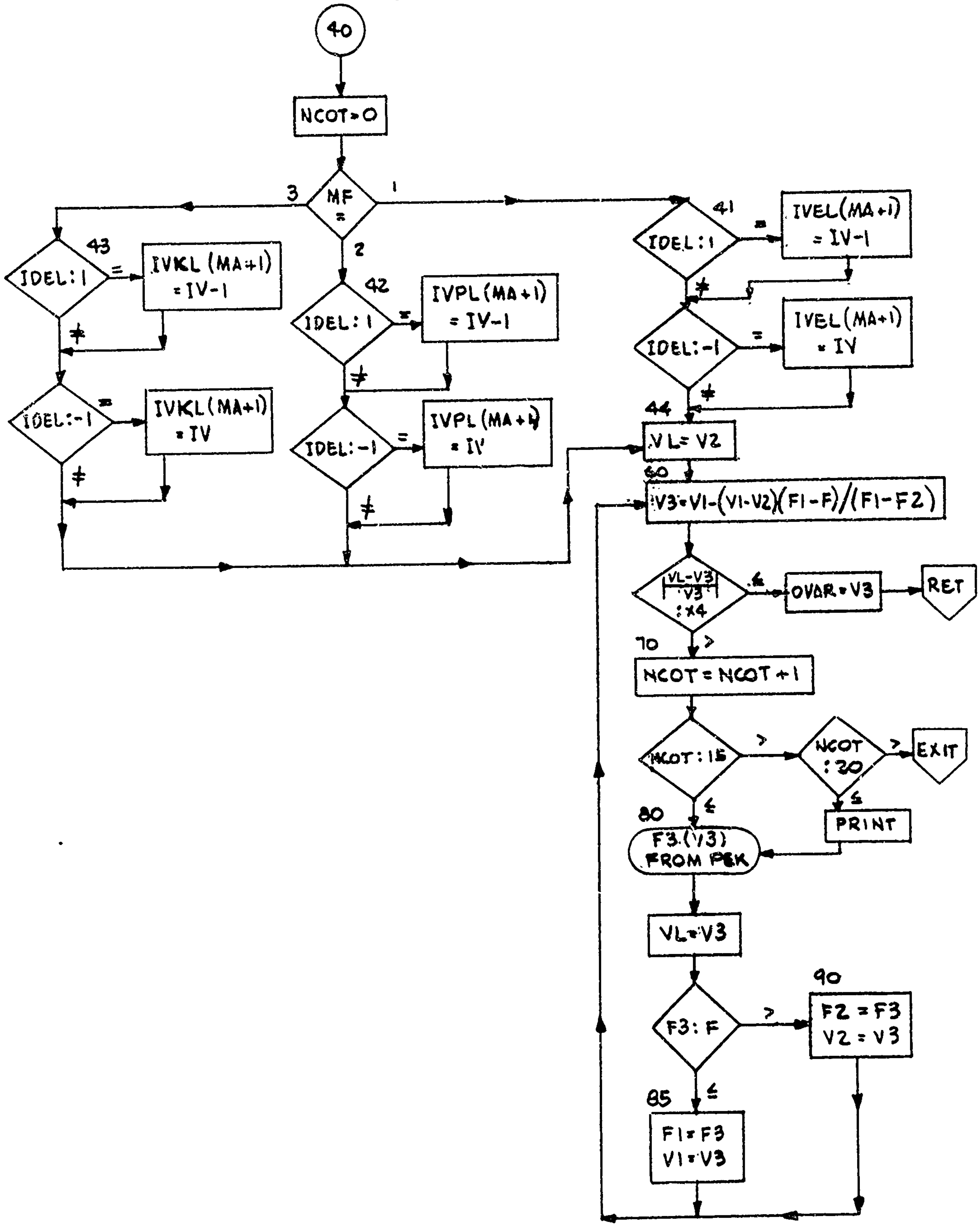
```
100  ITS=IBEGT(MF,ITAB)
     NTS=IBEGV(MF,ITAB)-ITS
     IDEL=1
     GO TO(101,102,103),MF
101  IT=ITPL(MA+1)
     IF(ITPL(MA+1).EQ.0) IT=ITS
     IF(F.LT.PTL(MA+1)) GO TO 106
     PTL(MA+1)=F
     GO TO 104
106  IDEL=-1
     IT=IT+1
     PTL(MA+1)=F
     GO TO 104
102  IT=ITEL(MA+1)
     IF(ITEL(MA+1).EQ.0) IT=ITS
     IF(F.LT.ETL(MA+1)) GO TO 107
     ETL(MA+1)=F
     GO TO 104
107  IDEL=-1
     IT=IT+1
     ETL(MA+1)=F
     GO TO 104
103  IT=ITKL(MA+1)
     IF(ITKL(MA+1).EQ.0) IT=ITS
     IF(F.LT.FKTL(MA+1)) GO TO 108
     FKTL(MA+1)=F
     GO TO 104
108  IDEL=-1
     IT=IT+1
     FKTL(MA+1)=F
104  T1=C(IT)
     CALL PEK(MF,MA,T1,VAR,JV,0,F1,C)
     DO130 I=2,NTS
125  IT=IT+IDEL
     IF(IT.LT.ITS+NTS.AND.IT.GE.ITS) GO TO 127
     IF(IT.LT.ITS) GO TO 126
     IT=ITS
     T1=C(IT)
     CALL PEK(MF,MA,T1,VAR,JV,0,F1,C)
     GO TO 125
126  IT=ITS+NTS-1
     T1=C(IT)
     CALL PEK(MF,MA,T1,VAR,JV,0,F1,C)
     GO TO 125
127  T2=C(IT)
     CALL PEK(MF,MA,T2,VAR,JV,0,F2,C)
     IF(((F1.GE.F).AND.(F2.LE.F)).OR.((F1.LE.F).AND.(F2.GE.F)))GOTO14
     F1=F2
     T1=T2
```

```
  130  CONTINUE
       PRINT 7001
       CALL EXIT
  140  NCOT=0
       GO TO (141,142,143),MF
  141  IF(IDEL.EQ. 1) ITPL(MA+1)=IT-1
       IF(IDEL.EQ.-1) ITPL(MA+1)=IT
       GO TO 144
  142  IF(IDEL.EQ. 1) ITEL(MA+1)=IT-1
       IF(IDEL.EQ.-1) ITEL(MA+1)=IT
       GO TO 144
  143  IF(IDEL.EQ. 1) ITKL(MA+1)=IT-1
       IF(IDEL.EQ.-1) ITKL(MA+1)=IT
  144  TL=T2
  160  T3=T1-(T1-T2)*(F1-F)/(F1-F2)
      IF (ABS((TL-T3)/T3).GT.X4) GO TO 170
       OVAR=T3
       RETURN
  170  NCOT=NCOT+1
       IF(NCOT.LE.15) GO TO 180
       IF(NCOT.GT.20) CALL EXIT
       PRINT 7003, T1,T2,T3,F1,F2,F3,MA,JV,VAR
 7003  FORMAT(23HOT1, T2, T3, F1, F2, F3/6E16.7 /2I12,E16.7)
  180  CALL PEK(MF,MA,T3,VAR,JV,0,F3,C)
       TL=T3
       IF(F3.GT.F) GO TO 190
  185  F1=F3
       T1=T3
       GO TO 160
  190  T2=T3
       F2=F3
       GO TO 160
       END
```

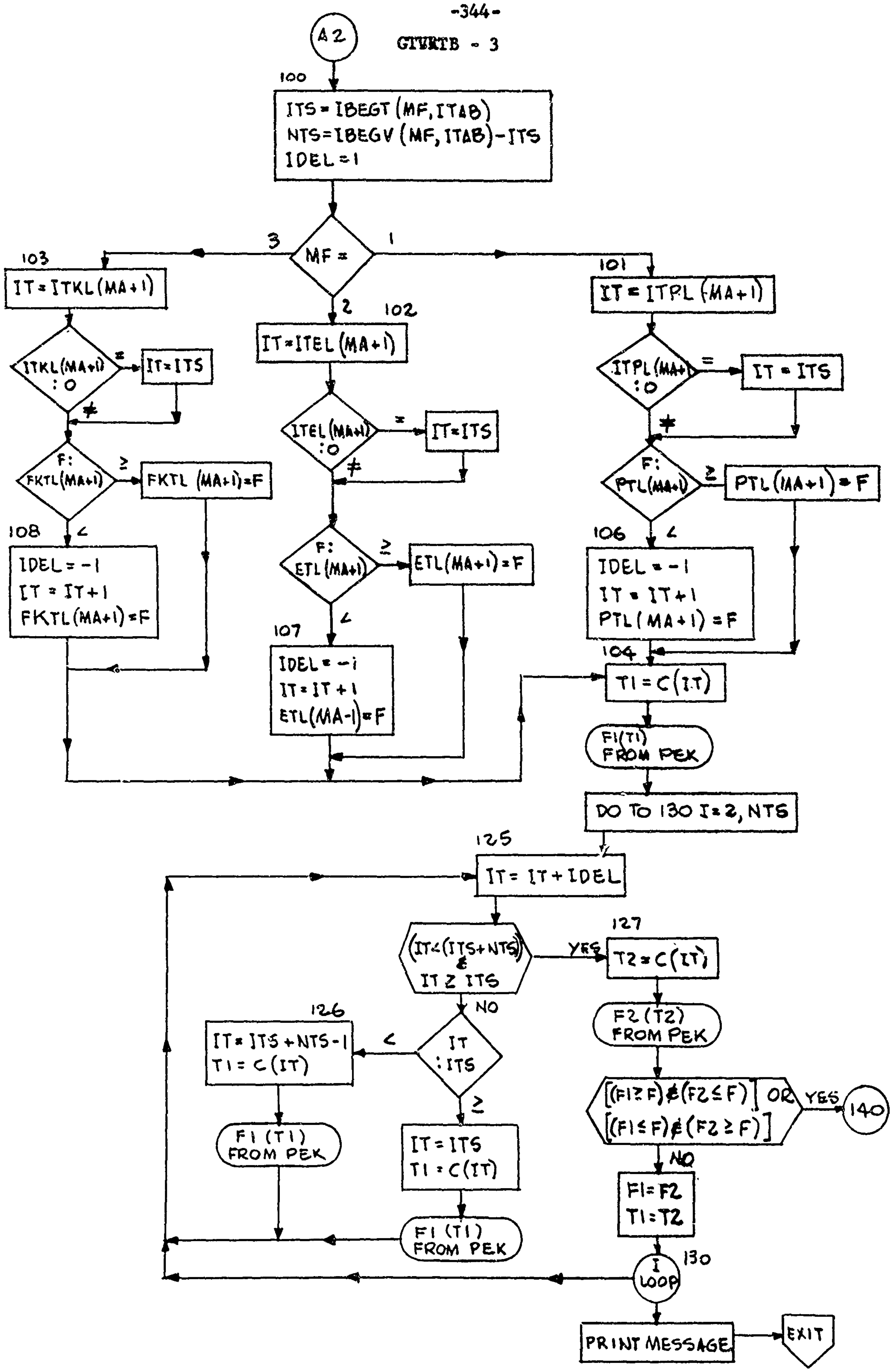
GTVRTB - 1


START
DO TO 10
FOR ITAB = 1,6
IDEOS MA+1
: IORDER ITAB
=
≠
10
ITAB LOOP
PRINT ERROR MESSAGE
EXIT
20
NV : 2
=
A2
≠
IVS = IBEGV (MF, ITAB)
NVS = (IBEGC (MF, ITAB) - IVS)
IDEL = 1
MF =
3
2
1
IV = IVKL (MA+1)
IVKL (MA+1) : 0
IV = IVS
F : FKVL (MA+1)
FKVL (MA+1) = F
8
IDEL = -1
IV = IV+1
FKVL (MA+1) = F
IV = IVEL (MA+1)
IVEL MA+1 : 0
IV = IVS
F : EVL (MA+1)
EVL (MA+1) = F
7
IDEL = -1
IV = IV+1
EVL (MA+1) = F
IV = IVPL (MA+1)
IVPL (MA+1) : 0
IV = IVS
F : PVL (MA+1)
PVL (MA+1) = F
6
IDEL = -1
IV = IV+1
PVL (MA+1) = F
4
V1 = C (IV)
F1 (V1) FROM PEK
DO TO 30 I = 2, NVS
25
IV = IV + IDEL
(IV < IVS + NVS) & (IV ≥ IVS)
YES
27
V2 = C (IV)
F2 (V2) FROM PEK
NO
26
IV = IVS + NVS - 1
V1 = C (IV)
IV : IVS
F1 (V1) FROM PEK
IV = IVS
V1 = C (IV)
F1 (V1) FROM PEK
[(F1 ≥ F) & (F2 ≤ F)] OR [(F1 ≤ F) & (F2 ≥ F)]
YES
NO
F1 = F2
V1 = V2
40
30
I LOOP
PRINT MESS.
EXIT

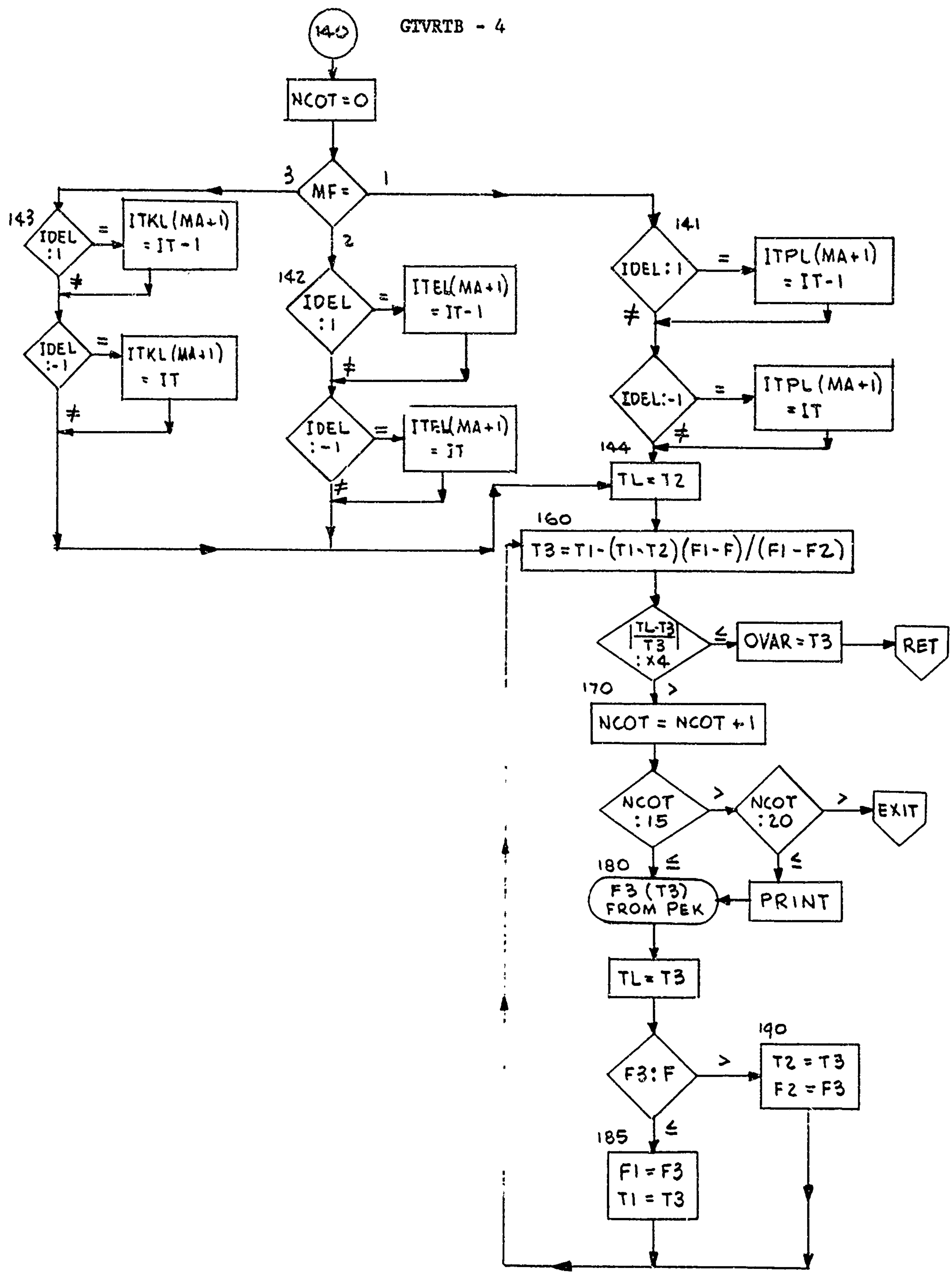
GTVRTB - 2


40
NCOT=0
MF
IDEL:1
IVKL (MA+1) = IV-1
IDEL:-1
IVKL(MA+1) = IV
IDEL:1
IVPL (MA+1) = IV-1
IDEL:-1
IVPL (MA+1) = IV
IDEL:1
IVEL(MA+1) = IV-1
IDEL:-1
IVEL(MA+1) = IV
VL= V2
V3=V1-(V1-V2)(F1-F)/(F1-F2)
OVAR=V3
RET
NCOT = NCOT +1
NCOT:15
NCOT :20
EXIT
PRINT
F3 (V3) FROM PEK
VL=V3
F3: F
F2 = F3
V2 = V3
F1=F3
V1=V3

GTVRTB - 3


A2
100
ITS = IBEGT (MF, ITAB)
NTS = IBEGV (MF, ITAB) - ITS
IDEL = 1
MF =
3
2
1
103
IT = ITKL (MA+1)
ITKL(MA+1) : 0
=
≠
IT = ITS
F: FKTL(MA+1)
≥
<
FKTL (MA+1) = F
108
IDEL = -1
IT = IT+1
FKTL(MA+1) = F
102
IT = ITEL (MA+1)
ITEL (MA+1) : 0
IT = ITS
F: ETL (MA+1)
ETL(MA+1) = F
107
IDEL = -1
IT = IT + 1
ETL(MA-1) = F
101
IT = ITPL (MA+1)
ITPL (MA+1) : 0
IT = ITS
F: PTL(MA+1)
PTL (MA+1) = F
106
IDEL = -1
IT = IT+1
PTL (MA+1) = F
104
T1 = C(IT)
F1(T1) FROM PEK
DO TO 130 I = 2, NTS
125
IT = IT + IDEL
(IT < (ITS+NTS) & IT ≥ ITS
YES
NO
127
T2 = C(IT)
F2 (T2) FROM PEK
[(F1 ≥ F) & (F2 ≤ F)] OR [(F1 ≤ F) & (F2 ≥ F)]
140
F1 = F2
T1 = T2
126
IT = ITS + NTS - 1
T1 = C (IT)
F1 (T1) FROM PEK
IT : ITS
IT = ITS
T1 = C(IT)
F1 (T1) FROM PEK
130
I LOOP
PRINT MESSAGE
EXIT

GTVRTB - 4


140
NCOT=0
MF=
3
1
2
143
IDEL :1
ITKL(MA+1) = IT-1
IDEL :-1
ITKL(MA+1) = IT
142
IDEL :1
ITEL(MA+1) = IT-1
IDEL :-1
ITEL(MA+1) = IT
141
IDEL:1
ITPL(MA+1) = IT-1
IDEL:-1
ITPL(MA+1) = IT
144
TL=T2
160
T3=T1-(T1-T2)(F1-F)/(F1-F2)
|(TL-T3)/T3| :X4
OVAR=T3
RET
170
NCOT = NCOT + 1
NCOT :15
NCOT :20
EXIT
180
F3 (T3) FROM PEK
PRINT
TL=T3
F3: F
190
T2 = T3
F2 = F3
185
F1 = F3
T1 = T3

42. IKAERR

IKAERR is called by ALIBI when a necessary subroutine is found missing. It prints the message "ALIBI HAS BEEN REACHED."

```
$IBFTC IKAERR  REF
       SUBROUTINE IKAERR
      PRINT 7000
 7000 FORMAT (24H0ALIBI HAS BEEN REACHED. )
      CALL EXIT
      END
```

43. ALIBI

ALIBI contains entry point to all routines which may be omitted. It should be loaded last.

```
$IBFTC ALIBI   REF
      SUBROUTINE ALIBI
      CALL IKAERR
      RETURN
      END
$IBFTC FP1000
      FUNCTION FP1000(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1001
      FUNCTION FP1001(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1002
      FUNCTION FP1002(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1003
      FUNCTION FP1003(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1004
      FUNCTION FP1004(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FP1005
      FUNCTION FP1005(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC FE1000
      FUNCTION FE1000(T,V)
      CALL IKAERR
      RETURN
      END
```

```
$IBFTC FE1001
       FUNCTION FE1001(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FE1002
       FUNCTION FE1002(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FE1003
       FUNCTION FE1003(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FE1004
       FUNCTION FE1004(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FE1005
       FUNCTION FE1005(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FK1000
       FUNCTION FK1000(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FK1001
       FUNCTION FK1001(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FK1002
       FUNCTION FK1002(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FK1003
       FUNCTION FK1003(T,V)
       CALL IKAERR
       RETURN
       END
$IBFTC FK1004
       FUNCTION FK1004(T,V)
       CALL IKAERR
       RETURN
       END
```

```
$IBFTC FK1005
      FUNCTION FK1CC5(T,V)
      CALL IKAERR
      RETURN
      END
$IBFTC DRCA
      SUBROUTINE RUA(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DPET
      SUBROUTINE PET
      CALL IKAERR
      RETURN
      END
$IBFTC DTSR
      SUBROUTINE TSR(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DROAXP
      SUBROUTINE ROAEXP(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DTSRXP
      SUBROUTINE TSREXP(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DCDR
      SUBROUTINE CDR(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DROAMP
      SUBROUTINE ROAIMP(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DROB
      SUBROUTINE ROB(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DROC
      SUBROUTINE ROC(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DRDI
      SUBROUTINE RDI(C)
```

```
      CALL IKAERR
      RETURN
      END
$IBFTC DROD
      SUBROUTINE ROD(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DROE
      SUBROUTINE ROE(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DTSRMP
      SUBROUTINE TSRIMP(C)
      CALL IKAERR
      RETURN
      END
$IBFTC DRBND
      SUBROUTINE RBOUND(TM,RHO)
      CALL IKAERR
      RETURN
      END
$IBFTC DPBND
       SUBROUTINE PBOUND (TM,PRJMP2)
      PRJMP2 = 0.
      RETURN
      END
$IBFTC DZNSRF
      FUNCTION ZNSRFN(J,SFN)
      ZNSRFN=0.
      RETURN
      END
$IBFTC DRGSRF
      FUNCTION RGSRFN(NR,SFN)
      RGSRFN=0.
      RETURN
      END
```

VII. TABCOE PROGRAM DESCRIPTION

PURPOSE

TABCOE is a code which generates interpolation coefficients from tabular equations of state. The input is an equation of state on a binary tape or on cards; the output is a binary tape containing the original equation of state data plus the calculated interpolation coefficients. This is a special purpose routine for use in conjunction with HAROLD.

Input units for generating the TABCOE values are as follows for Tables 1 and 2:

T's: Kev

ρ's: g/cc

P's: 10^{16} ergs/cc

E's: 10^{16} ergs/gm

In Table 3, 1/T is input instead of T, ρ in g/cc, K in cm^2/gm.

Output units are as follows:

T in 10^4 °K in Tables 1 and 2; 1/T(10^4 °K) in Table 3

ρ in g/cc

P in 10^{10} ergs/cc

E in 10^{10} ergs/gm

k in MMEGMS units $[m^2(10^4\ {}^\circ K)^4(\text{msec})^3/(\text{megagrams})^2]$

In HAROLD it is necessary to calculate F(T,V), $(\frac{\partial F}{\partial T})$ and $(\frac{\partial F}{\partial V})$. These are accomplished by using the interpolation coefficients as follows:

$$F(T,V) = a + b/v + ct + d/v^2 + et^2 + ft/v + gt/v^2 + ht^2/v + ot^2/v^2,$$

$$(\frac{\partial F}{\partial T}) = c + 2et + f/v + g/v^2 + 2ht/v + 2\cdot ot/v^2$$

and

$$(\frac{\partial F}{\partial V}) = b + 2d/v \quad t + 2gt/v + ht^2 + 2\cdot ot^2/v.$$

The input table looks like:

T_1	$f_{1,1}$	$f_{1,2}$	$f_{1,3}$	$f_{1,4}$	$f_{1,5}$	$f_{1,6}$	...	$f_{1,n}$
T_2	$f_{2,1}$	$f_{2,2}$	$f_{2,3}$	$f_{2,4}$	$f_{2,5}$	$f_{2,6}$	...	$f_{2,n}$
T_3	$f_{3,1}$	$f_{3,2}$	$f_{3,3}$	$f_{3,4}$	$f_{3,5}$	$f_{3,6}$	...	$f_{3,n}$
T_4	$f_{4,1}$	$f_{4,2}$	$f_{4,3}$	....	....	....	...	....
T_5	$f_{5,1}$	$f_{5,2}$	$f_{5,3}$	....	....	....	...	....
T_6	$f_{6,1}$	$f_{6,2}$	$f_{6,3}$	....	....	....	...	....
T_7	$f_{7,1}$	$f_{7,2}$	$f_{7,3}$	....	....	....	...	....
$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$	$\vdots$
T_m	$f_{m,1}$	$f_{m,2}$	$f_{m,3}$	....	....	....	...	$f_{m,n}$
	ρ_1	ρ_2	ρ_3	ρ_4	ρ_5	ρ_6	...	ρ_n

where m and n must be odd. This table is divided into "macro-boxes," as indicated by the dotted lines. A set of nine interpolation coefficients is determined by the nine function values in each macro-box. The macro-boxes containing the T,ρ pairs and their associated coefficients overlap on all contiguous edges. If m= the number of temperatures and n= the number of densities, the total number of macro boxes will be (m-1) x (n-1)/4.

METHOD

The matrix equation

$$\begin{bmatrix}
1 & \rho_1 & T_1 & \rho_1^2T_1^2 & T_1\rho_1 & \rho_1^2T_1 & T_1^2\rho_1 & T_1^2\rho_1^2 \\
1 & \rho_2 & T_1 & \rho_2^2T_1^2 & T_1\rho_2 & \rho_2^2T_1 & T_1^2\rho_2 & T_1^2\rho_2^2 \\
1 & \rho_3 & T_1 & \rho_3^2T_1^2 & T_1\rho_3 & \rho_3^2T_1 & T_1^2\rho_3 & T_1^2\rho_3^2 \\
1 & \rho_1 & T_2 & \rho_1^2T_2^2 & T_2\rho_1 & \rho_1^2T_2 & T_2^2\rho_1 & T_2^2\rho_1^2 \\
1 & \rho_2 & T_2 & \rho_2^2T_2^2 & T_2\rho_2 & \rho_2^2T_2 & T_2^2\rho_2 & T_2^2\rho_2^2 \\
1 & \rho_3 & T_2 & \rho_3^2T_2^2 & T_2\rho_3 & \rho_3^2T_2 & T_2^2\rho_3 & T_2^2\rho_3^2 \\
1 & \rho_1 & T_3 & \rho_1^2T_3^2 & T_3\rho_1 & \rho_1^2T_3 & T_3^2\rho_1 & T_3^2\rho_1^2 \\
1 & \rho_2 & T_3 & \rho_2^2T_3^2 & T_3\rho_2 & \rho_2^2T_3 & T_3^2\rho_2 & T_3^2\rho_2^2 \\
1 & \rho_3 & T_3 & \rho_3^2T_3^2 & T_3\rho_3 & \rho_3^2T_3 & T_3^2\rho_3 & T_3^2\rho_3^2
\end{bmatrix}
\begin{bmatrix} a \\ b \\ c \\ d \\ e \\ f \\ g \\ h \\ o \end{bmatrix}
=
\begin{bmatrix} f(T_1,\rho_1) \\ f(T_1,\rho_2) \\ f(T_1,\rho_3) \\ f(T_2,\rho_1) \\ f(T_2,\rho_2) \\ f(T_2,\rho_3) \\ f(T_3,\rho_1) \\ f(T_3,\rho_2) \\ f(T_3,\rho_3) \end{bmatrix}$$

is solved for a, b, c, d, e, f, g, h, and o.

INPUT DATA

Card 1: KDIRCT, KINTPE, KOPT, KOUTPE, KPRINT

FORMAT: (5I6).

KDIRCT: 1 if output is to go on a previously used binary tape.
2 if a new binary tape is to be used.

KINTPE: Logical tape designation of binary input tabe (must be positive even if cards are used).

KOPT: 1 if input is on tape. 2 if input is on cards.

KOUTPE: Logical tape designation of binary output tape.

KPRINT: 1 if results are not to be printed. 2 if results are to be printed.

Card 2: IDIN, IDOUT.

FORMAT: (5I6).

IDIN: ID number of an input equation of state.

IDOUT: ID number to be associated with it on the output equation of state.

If the equation of state is to be input via cards, the equation of state with ID number IDNO comes next, followed by another card 2 and another equation of state, etc.

The equation of state cards are of the form:

IDNO, NTAB, NTEMP1, NRHO1

$TEMP1_1$, $TEMP1_2$, ...$TEMP1_{NTEMP1}$

$RHO1_1$, $RHO1_2$, ...$RHO1_{NRHO1}$

$P_{1,1}$, $P_{2,1}$, ...$P_{NTEMP1,1}$

$P_{1,2}$, $P_{2,2}$, ...$P_{NTEMP1,NRHO1}$

. .
. .
. .

$P_{1,NRHO1}$, $P_{2,NRHO1}$, ...$P_{NTEMP1,NRHO1}$

IDNO, NTAB, NTEMP2, NRHO2

TEMP2, $TEMP2_2$, ..., $TEMP2_{NTEMP2}$

$RHO2_1$, $RHO2_2$, ..., $RHO2_{NRHO2}$

$E_{1,1}$, $E_{2,1}$, ..., $E_{NTEMP2,1}$

$E_{1,2}$, $E_{2,2}$, ..., $E_{NTEMP2,2}$

.
.
.

$E_{1,NRHO2}$, $E_{2,NRHO2}$, ..., $E_{NTEMP2,NRHO2}$

and similarly for K, where IDNO is the equation of state ID and NTAB is 3 for K. The format for the first card of each section is (I3, I1, 2I2) and for all the others (5E14.7).

If the equations of state are on a binary tape, there should be two records for each equation of state equation.

1. IDENT, NTAB, NTEMP1, NRHO1
2. $TEMP1_1$, $TEMP1_2$, ... $TEMP1_{NTEMP1}$, $RHO1_1$, $RHO1_2$, ..., $RHO1_{NRHO1}$, $P_{1,1}$, $P_{2,1}$, ..., $P_{NTEMP1,1}$, $P_{1,2}$, $P_{2,2}$, $P_{NTEMP1,2}$, ...; $P1_{NRHO1}$, $P_{2,NRHO1}$, ..., $P_{NTEMP1, NRHO1}$

for pressure and similar terms for energy and opacity.

OUTPUT

The term of the output tape is:

Record 1: IDOUT, NTAB, NTEMP, NRHO

Record 2: T_i i = 1, NTEMP, R_i i = 1, NRHO

Record 3: $f_{1,1}, f_{2,1}, \ldots, f_{NTEMP,1}$

$f_{1,2}, f_{2,2}, \ldots, f_{NTEMP,2}$

$\vdots$

$f_{1,NRHO}, f_{2,NRHO}, \ldots, f_{NTEMP, NRHO}$

Record 4: $a_{1,1}, b_{1,1}, \ldots, o_{1,1}$

$a_{2,1}, b_{2,1}, \ldots, o_{2,1}$

$\vdots$

$a_{NT,1}, b_{NT,1}, \ldots, o_{NT,1}$

$a_{1,2}, b_{1,2}, \ldots, o_{1,2}$

$a_{2,2}, b_{2,2}, \ldots, o_{2,2}$

$\vdots$

$a_{NT,2}, b_{NT,2}, \ldots, o_{NT,2}$

$\vdots$

$a_{1,NR}, b_{1,NR}, \ldots, o_{1,NR}$

$a_{2,NR}, b_{2,NR}, \ldots, o_{2,NR}$

$\vdots$

$a_{NT,NR}, b_{NT,NR}, \ldots, o_{NT,NR}$

where NT = (NTEMP-1)/2 and NR = (NRHO-1)/2.

VIII. NOTES FOR FORTRAN VERSION

For greater flexibility in HAROLD, some of the subroutines are written in the MAP language. Since MAP is a coding language available only under IBSYS,we have rewritten these routines in FORTRAN for our less fortunate brethren.

We will explain the functions of the MAP routines, note the corresponding loss of flexibility, if any, in FORTRAN, and, in the case of those routines which are untranslatable into FORTRAN, attempt to indicate what the user's new responsibilities will be.

SUBROUTINES COMSIZ

The first routine to be affected will be COMSIZ. This routine must appear first in both the Generator and Executor portions of HAROLD. Its function, in essence, is to set up a labeled common with dimensions for all the zone variables used in the problem. The advantage of coding in MAP is that by changing one card the entire problem may be redimensioned.

For example: a COMMON statement in FORTRAN

```
COMMON/RC/ R(202)
```

may be translated into MAP as:

```
SIZE   EQU      202
RC     CONTRL   R, R+SIZE
R      BSS      SIZE
```

To change the dimensions of R you must change the number in brackets in the FORTRAN statement and change the value of SIZE in MAP. In the case of one variable it hardly matters whether you use FORTRAN or MAP. However, if you have many variables with the same dimension, you must change every bracket in the FORTRAN COMMON statement but still need only to change the value of SIZE in MAP.

The COMSIZ routine in the Executor portion of HAROLD has three variables which may be adjusted viz., SIZE, SIZEE, and SIZEI for hydrodynamics, explicit and implicit radiation respectively. SIZE delimits the dimensions of the variables used for all problems. If

you are running a hydro only problem and need more storage space for tables, SIZEE and SIZEI may be set to zero. The hierarchy of variables is such that: SIZE is adjustable but never zero,

SIZEE is zero if and only if hydro only,

SIZEI is zero if and only if (hydro only or explicit only).

At the most only three cards must be changed in order to redimension the problem. In FORTRAN every dimension must be altered.

In addition to setting up COMMON statements the MAP version of COMSIZ in the Executor had a table which contained the conversion factors for the various output units that were permissible in MAP. This section of COMSIZ is omitted in the FORTRAN version because the user must write his own output format and arrange the conversion of the variables he wants output to the appropriate units.

Finally, in both versions of COMSIZ the statements COMMON/CTABLE/ C(5000) (where 5000 is some appropriate number) gives you the dimensions of the tabular equations of state. Previously the subroutines GMAIN and EMAIN calculated the total amount of unused core after the problem had been loaded and supplied this number as the maximum dimensions of the tabular equations of state. The FORTRAN user will have to determine this number for himself and then supply it to the common statement.

(Note: If the above remarks have not already made it clear, the COMSIZ for the Generator is not the same as the COMSIZ for the Executor.)

SUBROUTINE HOLWD

In essence, HOLWD is a COMMON. It is never executed. It contains the BCD images of all data card titles and variable labels. Because we have this Hollerith information stored in BCD form, we are able to test for the Hollerith value of any data card title of variable label, in the same way we would test the relative values of any two pieces of BCD information.

The Generate portion of HAROLD contains many subroutines which are devoted exclusively to the reading and interpretation of Generate data cards. For example:

STREAD - the start card

CYCRED - the history edit, print out and energy edit cards
TMREAD - the time step card
UNTRED - the units card (not in FORTRAN version)
GEOM - the geometry card
RMREAD - the RMIN card
EOSNRD - the EOS card
REGNRD - the region and zone cards
SOURCE - the source cards
BOUND - the boundary minimum and/or maximum cards
COMB - the combination card
TMPRED - the temperature card
PERC - the percents card

All that the above subroutines do is interpret the particular card they represent. If, for instance, RMIN=0, you do not need an RMIN card and consequently you never go to the subroutine RMREAD.

It is because of HOLWD--Hollerith word--that the I/O scheme for HAROLD is so extremely flexible. Each data card is read in at a gulp in format 12A6 (MAP version). All data card titles appear as Hollerith words in columns 1-6. To decide which card we are reading is a simple matter of elimination due to HOLWD. We start with the BCD image of the first possible data card and by making the test

```
IF (CARD(1).EQ.STARTB) GO TO STREAD
```

we literally subtract the BCD image of START as contained in HOLWD from the BCD image on CARD(1). If the value is zero, we know we are reading the START card; if not, we follow with another test

```
IF (CARD(1) EQ.HISTOR) GO TO CYCRED, etc.
```

If some card that must be present is not, we get a message telling us so. Otherwise the programmer need put in only those cards which apply to his particular problem. For instance, a plane geometry problem, with RMIN=0, no tabular equations of state, no source functions and no boundary conditions needs only the following cards:

MAP Version	FORTRAN Version
START	START
HISTORY EDIT	HISTOR
PRINT OUT	PRINT
ENERGY EDIT	ENERGY
TIME STEP	TIME S
REGION (ZONE if appropriate)	REGION
COMBINATION	COMBIN
ZTEMPERATURE	ZTEMPE
PERCENTS	PERCEN
ENDATA	ENDATA

There is also extreme flexibility in the numbers and kinds of variables which are included on a particular data card. All variable names appear in cols. 13-15, 28-30, 43-45, 58-60. The values associated with a given variable occupy the 12 columns immediately following it. For example, if T= appeared in cols. 13-15 the value of Temp will be in cols. 16-27.

The method of establishing the identity of the variable is identical to the method used in identifying the title of a particular card. Its logic is slightly more sophisticated in that there are four possible locations for variable labels on a particular data card, whereas all card titles appear in cols. 1-6. The subroutine responsible for reading a particular card reaches in and picks out of the entire card image the contents of cols. 13-15. It then tests the information found there against the BCD image of every possible variable label that can appear on the card. When a match is found, the subroutine plucks the value of the variable from cols. 16-27 and stores it in the correct place. It then moves over to the next field, i.e., cols. 28-30, and repeats the testing process.

Without HOLWD there would have to be a fixed set of data cards, all containing specific and inflexible information. The Generate section of HAROLD would contain 13 fewer subroutines, and the user of HAROLD simply wouldn't bother.

The Generate section becomes much less formidable when the user realizes that much of it is just searching card labels and columns to identify input information. HOLWD contains the BCD images of all Hollerith information which can appear in the Generate data.

The MAP version of HOLWD looks like this:

```
RION      CONTROL     REGION, REGION+1
REGION    BCI         1, REGION
PNTB      CONTROL     PRINT, PRINTB+1
PRINTB    BCI         1, PRINT
TQ        CONTROL     TEQ, TEQ+1
TEQ       BCI         1, T=
```

The FORTRAN version of HOLWD accomplishes the same job in the following way:

```
Subroutine HOLWD
     COMMON/PNTB/PRINTB
     DATA/PRINTB/6HPRINT /
     COMMON/RION/REGION
     DATA REGION/6HREGION/
     COMMON/TQ/TEQ
     DATA TEQ/6HT=      /
```

SUBROUTINE GMAIN (The same discussion will apply to SUB EMAIN)

GMAIN is the entry point into the Generator. It calls GENRAT with the arguments C and LIMIT. C is the address of the first cell in unused core after loading. LIMIT is a number calculated by subtracting C from the last address in unused core. When tabular equations of state were used the size of the tables were compared to LIMIT, the maximum possible storage space. If they were found to be too big some adjustment in dimensioning could be made in COMSIZ. In any case, you always had the maximum storage space for tables under the conditions of the problem.

This flexibility is not available to non-IBSYS users and GMAIN now dimensions the tables with a constant by means of the statements DIMENSION C(2000) (where 2000 may be determined by the user) and LIMIT=2000. It then calls HOLWD which sets up Hollerith commons, and, finally, calls GENRAT (C,LIMIT).

SUBROUTINE GETLAB (I, J, A) (MAP Version)

All data cards are read into the machine by means of the following statement:

```
      DIMENSION CARD (12)
      READ 1, CARD
1     FORMAT (12A6)
```

As a result of calling HOLWD in GMAIN all Hollerith literals are in common. Each data card is read as 12 Hollerith words. CARD(1) represents the first field of 6 letters. This field will either be blank or contain the title of the data card, e.g., REGION. CARD(2) represents the second field of 6 and is significant only on certain cards. For example, on the REGION card CARD(2) contains the material number of the equation of state used in that region. CARD(3) represents columns 13-18. CARD(4) represents columns 19-24, and so on up to CARD(12), columns 67-72.

Now all variable names (labels) occupy the following, and only the following, columns on the data cards.

Cols. 13-15, 28-30, 43-45, 58-60.

The function of GETLAB is to determine which variable we are reading and then CONVRT assigns its associated value to the variable just identified by GETLAB.

To read cols.	13-15 we are concerned with	CARD(3)	format (A3)
	28-30	CARD(5)	(3X,A3)
	43-45	CARD(8)	(A3)
	58-60	CARD(10)	(3X,A3).

To illustrate: CARD(5) represents cols. 25-30. We are interested only in cols. 28-30, i.e., (3X,A3). CARD(8) represents col. 43-48, we need 43-45 or convert CARD(8) to (A3). Once again you are referred to REGNRD to appreciate the logic involved here.

GETLAB is called with the arguments I, J, A. I and J must be one of the following pairs:

I	J
13	15
28	30
43	45
58	60

A is determined in GETLAB and returned as WLAB which is then tested for all possible variables that might appear on the card. Once the identity of the variable has been established its value is determined by CONVRT.

SUBROUTINE CONVRT (I,J,A) (MAP Version)

I is the value of FIELDN in the routine which calls CONVRT. FIELDN is a flag which corresponds to the appropriate field on the card you are reading and has the values 1, 2, 3, or 4.

FIELDN=1 corresponds to cols.	16-27 corresponds to	I=1
2	31-42	2
3	46-57	3
4	61-72	4

J has the value 1 or 2 depending whether you want a fixed or floating point conversion. A, which was established in GETLAB, is the name of the variable whose value is to be returned by CONVRT. For example, suppose we are reading a REGION card and we find that the variable in cols. 28-30 is "J=". We know the value of J is a fixed point number lying in cols. 31-42, so CALL CONVRT (2,1,JREG(REGNO)). If the variable in Cols. 58-61 were "RH=" we know that the value of rho is floating point and lies in cols. 61-72 and we would CALL CONVRT(4,2,RHVAL).

EMAIN

Same comments apply as made for GMAIN.

ESTAB AND FORMS

Set up output units and formats in the MAP version which were requested by the user via the output description data deck at the end of EXEC data package. Forms is not translatable into FORTRAN and the user will now be responsible for his own output units and formats which he will specify in the following subroutine.

SUBROUTINE PROUT (C)

This subroutine contains the COMMONS for all the necessary output variables. The user must prepare his own output here. Attached is a sample PROUT to reproduce the output of Example 1.

```
$IBFTC PROUT   REF
      SUBROUTINE PROUT(C)
       COMMON /IKA2/ ERS(6,10), ES(6,10), TMRS(6,10), TMS(6,10), RS(10),
     1 JS(10), NRS(10), NZS(10), RRG(15), JREG(15), C1(15), C2(15),
     2 C3(15), C4(15), C5(15), E0(15), EMIN(6), EMAX(6), KMIN(6),
     3 KMAX(6), PMIN(6), PMAX(6), TMIN(6), TMAX(6), UMIN(6), UMAX(6),
     4TEMIN(6), TEMAX(6), TKMIN(6), TKMAX(6), TPMIN(6), TPMAX(6), NKMAX,
     5 TTMIN(6), TTMAX(6), TUMIN(6), TUMAX(6), NEMIN, NEMAX, NKMIN,
     6 NPMIN, NPMAX, NTMIN, NTMAX, NUMIN, NUMAX, NRSRCE, NZSRCE,
     7 JO, JOS, JOM, DRC, Z1, Z2, JL, X1, X2, X3, X4, X5, X6, NS,NF,
     8 UNCGS, UNMKS, TM, DT, DTP, JSTAR, JHAT, JMAX, DELTA, REGNO, JZ,
     9 NREG, NEOS, RMIN, RMAX, IRAD
      COMMON /MATC/ MAT(1)
      COMMON /RC/   R(1)
      COMMON /UC/   U(1)
      COMMON /TEMC/ TEM(1)
      COMMON /VLC/  VL(1)
      COMMON /PRC/  PR(1)
      COMMON /EGC/  EG(1)
      COMMON /QC/   Q(1)
      COMMON /DMASSC/ DMASS(1)
      DIMENSION C(1)
      DIMENSION RH(202)
      JMAX2 = JMAX+2
      DO 500 J=1,JMAX2
      RH(J) = 1./VL(J)
  500 TEM(J) = .139*EG(J)
      WRITE(6,101)
  101 FORMAT (3H0 J,6X,6HRADIUS,9X,8HVELOCITY,8X,7HDENSITY,9X,4HTEMP,
     1  10X,6HINTENG,8X,8HPRESSURE,8X,6HARTVIS,10X,4HMASS )
      K=0
      WRITE (6,102) K,R(1),U(1),RH(1),TEM(1),EG(1),PR(1),Q(1),DMASS(1)
      I=1
      J=2
   20 WRITE (6,103) MAT(J)
  103 FORMAT (13HOMATERIAL    I4)
   10 K=J-1
      WRITE (6,102) K,R(J),U(J),RH(J),TEM(J),EG(J),PR(J),Q(J),DMASS(J)
  102 FORMAT (I3,1PE15.5,1P7E15.3)
      J=J+1
      IF (J.GT.JHAT+3) GO TO 30
      IF (J.LE.JREG(I)+1) GO TO 10
      I=I+1
      IF (I.LE.NREG) GO TO 20
   30 WRITE (6,104)
C
  104 FORMAT (6H0    N,10X,4HTIME ,12X,2HDT ,11X,6HLAMBDA,5X,4HJLAM ,6X,
C
     1 5HOMEGA ,4X,6HJOMEGA,6X,5HGAMMA,4X,4HJGAM ,3X,2HJO,2X,5HJSTAR,2X,
C
     2 4HJHAT ,3X,2HIC )
C
      RETURN
      END
```

SUBROUTINE ALIBI (for the MAP version)

ALIBI is a routine which contains a dummy entry point for every subroutine in HAROLD. This routine enables the problem user to include only those subroutine's which he needs in his particular problem. There are two important advantages in having ALIBI:

1. Not having to LOAD all subroutines saves space.
2. Not having to LOAD all subroutines saves time.

At loading time the machine checks through its reference dictionary and confirms that every call statement has something to call, regardless of the fact that the call statement may never be executed. WHEN, for example, in EXEC the machine finds a CALL ROAIMP statement but there is no ROAIMP deck included, the LOADER will refuse to LOAD the problem. If you were doing hydrodynamics only, you would use subroutine ROA and not ROAIMP. ALIBI will provide a dummy entry point for ROAIMP and you would not have to include the deck. For this reason ALIBI must be loaded LAST. If, on the other hand, in this hydro only problem, you forgot to include the deck ROA, when ROA was called, you would go to its dummy entry point in ALIBI, which would send you in then to IKAERR, which prints the message "ALIBI HAS BEEN REACHED." You would then have to figure out which deck you left out.

ALIBI does have a couple of smarts. For instance there are some subroutines which are always called but do not necessarily need to be present. ZONSR or REGSR are examples. These routines provide the ZONE/REGION source/sink terms and are called by CDR, ROA and other subroutines. If there are no sources or sinks in the problem, the dummy subroutines in ALIBI set the values to zero and do not go to IKAERR. In FORTRAN dummy entry points can only be created by dummy subroutines. In MAP a dummy entry point can be created by means of the EXTERN statement unavailable to FORTRAN users. The function of ALIBI is now assumed by a set of dummy subroutines which follow $IBLDR ALIBI. ALIBI itself exists only as an index separating the real subroutines from the dummys.

SUBROUTINE CLNUP(I,ISSW5) TO SUBROUTINE CLNUP(I,J)

When a job is submitted with a time estimate, the machine is set to kick it off at the end of the requested time. This can often be in the middle of a calculation, the results of which could be lost. The MAP VERSION of CLNUP would check the interval timer for overflow at the end of each cycle. If, in fact, it had overflowed, CLNUP would reset it to allow one more minute and then take a history edit, print out and CALL EXIT.

This routine is a function of our system here at RAND--other installations may have a similar system subroutine, in which case the user may modify HAROLD to use it. In other instances no such facility exists, with the consequence that no extra time may be alloted. The user with this handicap must exercise caution to provide histories as frequently as necessary or terminate his job on NF.

SUBROUTINE BCDCON(A) (MAP Version)

Up to now we have discussed some of the annoying details with which the FORTRAN user must burden himself. The difficulties which the loss of BCDCON will present make the rest of them vanish like booze in a dry country.

This subroutine is the most crucial link in the chain of I/O flexibility. Because of BCDCON we may read in all the Generate data cards with format 12A6 and then go back and pick up bits and pieces of information from this card and translate it into fixed, or floating point numbers or Hollerith characters, as we choose. BCDCON is the guts of GETLAB and CONVRT. It is also called by other Generate subroutines.

Unfortunately, BCDCON is a RAND modification of RWD, the IBM conversion routine which is included in the IBSYS package. What BCDCON does is the following:

1. Sets up an internal file, represented by TAPE 99.
2. Writes its argument on this buffer and returns you to its calling subroutine.
3. The calling subroutine then reads the argument from this buffer according to any format desired.

For example, GETLAB calls BCDCON with four different arguments viz., CARD(3), CARD(5), CARD(8) and CARD(10) representing the image on the input cards from Cols. 13-18, 25-30, 43-58, 55-60, respectively. GETLAB is concerned only with the Hollerith labels in Cols. 13-15, 28-30, 43-45, and 58-60, respectively. So, if we are trying to ascertain the contents of Cols. 28-30, we would call BCDCON (CARD(5)) which would dump the image in Cols. 25-30 onto TAPE 99. We then return to GETLAB which reads 99 according to the format (3X,A3). CONVRT works the same way but is concerned with different columns and fixed or floating point numbers. BCDCON has four restrictions.

1. No I/O statements may appear between the initializing CALL BCDCON(X) and the READ 99 statement which follows the call.
2. Only one logical record may be read or written.
3. The argument of the initializing call may <u>not</u> appear in the list of the READ statement (e.g., if we call BCDCON(A) we may not READ(99,A).
4. Only one READ 99 may follow a BCDCON call.

If the users cannot come up with a routine which performs this function, the dire consequences are as follows:

1. The Generate data cards must be read in the following format (A6, F6.0, 4(A3,E12.6)). All fixed point numbers, such as J on the region card, are truncated from E12.6 to a fixed point format.
2. All routines which used BCDCON, GETLAB and CONVRT must be modified to accommodate the next fixed format and these three subroutines will be omitted.

In effect this means modification of all subroutines which are called as a consequence of testing a card label. Viz., STREAD, CYCRED, TMREAD, RMREAD, GEOM, EOSNRD, REGNRD, BOUND, SOURCE, TMPRED, PERC, COMB. We have done this for you by creating an all-FORTRAN monster but have added the above notes for your enlightenment in hopes that perhaps your particular system already has, with only minor modification, the facility to accomplish these tasks.

SUMMARY

In the FORTRAN version of HAROLD:

(1) The subroutines GETLAB, CONVRT, BCDCON are eliminated. Their functions are assumed by the subroutines themselves. For example, in the MAP version, we would read the whole data card in format (12A6). If we wished to identify the variables in cols. 31-42, first, we would use BCDCON and GETLAB to identify the label in cols. 28-30. In format (12A6) cols. 28-30 are the last half of Card(5). The Hollerith information we desire is converted via GETLAB (28,30,A) and BCDCON into format (3X,A3) and tested against the labels subroutine HOLWD has stored for us until identification occurs. Second, CONVRT (31,42,A) and BCDCON take the value of the now determined variable which is located in cols. 31-42 and stores it in the appropriate place. In the FORTRAN version we have changed

```
Read 1, (Card(I), I=1,12) or Read 1, Card(12)
1 Format (12A6)
to
Read 1, (Card(I), I=1,10)
1 Format (A6,F6.0),4(A3,E12.6)
```

Card(1) is the same in both versions
Card(2) is a floating point number in FORTRAN
Card(3) represents the variable label in cols.13-15 in FORTRAN
Card(4) represents the variable value in cols.16-27 in FORTRAN
Card(5) represents the variable label in cols.28-30
Card(6) represents the variable value in cols.31-42
Card(7) represents the variable label in cols.43-45
Card(8) represents the variable value in cols.46-57
Card(9) represents the variable label in cols.58-60
Card(10) represents the variable value in cols.61-72

FIELDN has the same function in FORTRAN as in MAP. I.e.,

```
FIELDN = 1  WLAB = Card(3)
FIELDN = 2  WLAB = Card(5)
FIELDN = 3  WLAB = Card(7)
FIELDN = 4  WLAB = Card(9)
```

WLAB is tested just as in MAP to identify the variable. Once this is accomplished you test for the value of FIELDN and assign the contents of the appropriate columns to be stored as the value of the variable. To illustrate:

Suppose you are reading the region card and you are interested in the identity and associated value of the variable in cols. 28-30, the value of FIELDN at this point will be 2. And the MAP version instructions will be the following:

CALL GETLAB (28,30 WLAB).

(GETLAB will call BCDCON which will take Card(5) and convert it via format (3X,A3) to the Hollerith label on cols. 28-30.) WLAB will be tested against all possible variable labels which can appear on a region card until a match is found. Let's say that the label turned out to be "J=" we would then call CONVRT (FIELDN, 1, JREG(REGNO)). Since FIELDN=2 and the second argument is 1, CONVRT would take the contents of CARD(I),I=1,12, extract the value contained in cols.31-42 and have BCDCON convert it to a fixed point number which is returned to REGNRD as JREG(REGNO). The FORMAT statement which accomplishes this is FORMAT(30X,I12).

The FORTRAN instructions would be the following:

Since FIELDN=2, WLAB=Card(5), it is no longer necessary to go to GETLAB and BCDCON as the format of Card(5) is (A3) as expected. WLAB is tested just as in the MAP version and when a match is found, instead of call CONVRT (I,J,A), we have the four statements:

```
If (FIELDN.EQ.1)   JREG(REGNO) = Card(4)
If (FIELDN.EQ.2)   JREG(REGNO) = Card(6)
If (FIELDN.EQ.3)   JREG(REGNO) = Card(8)
If (FIELDN.EQ.4)   JREG(REGNO) = Card(10)
```

In our example JREG(REGNO) = Card(6) or the number in cols. 31-42. As you can see, this is more unwieldy but the effect is identical. All flow charts were done for the MAP version but the logic remains unchanged. WLAB from GETLAB gets replaced by WLAB = Card(N) where

N = 3 if FIELDN = 1

N = 5 if FIELDN = 2

N = 7 if FIELDN = 3

N = 9 if FIELDN = 4

and call CONVRT(FIELDN,J,A) is replaced by at least four statements depending on the subroutine. Also note the input formats in the flow charts are correct for the MAP version. These minor differences should not concern the user if he has carefully read the preceding section and uses the listings as his final arbiter.

(2) All output quantities and their units must be controlled in detail by the user via subroutine PROUT. All input units must be in MMEGMS (meters, megagrams, milliseconds).

(3) The user must exercise caution in the timing of history edits or in his selection of NF unless he has a system facility to compare with subroutine CLNUP which is in the MAP version only.

(4) Close attention must be given to the data card format in Generate. See page 121.

IX. HOW TO RUN "HAROLD"--A PROGRAMMERS POINT OF VIEW

HAROLD is run as two sequential IBJOB's. The Generate section is run first. Starting from NS=0 it creates a zero cycle on the history tape which contains all the initial conditions of the zone variables, and, all other parameters you have included in the Generate data package. For instance, all boundary conditions, step source functions, convergence criteria, etc., are interpreted in the Generate section of the program and stored on the history tape.

The Execute portion of HAROLD is where the work is done. It starts with the initial conditions established by Generate and proceeds to calculate and output per user specification. It is run as the second IBJOB.

Since the Generate package contains 65 subroutines and the Execute package contains 74 (all 74 never need to be loaded for a specific job), the physical handling of HAROLD can become extremely unwieldy. What we have done here at RAND to alleviate this problem, is to avail ourselves of the IBM UPDATE and IEDIT facilities in the following way.

All binary decks, i.e., the 65 Generate and the 74 Execute subroutines, have been updated onto a tape. By means of the IEDIT feature we select only those decks from the tape that we need for a particular job. In Generate alone this is a reduction from a card tray containing 65 subroutines, to perhaps 72 control cards.

We have also created a tape containing the more commonly used equations of state. Instead of manufacturing your own deck you may simply use the appropriate control cards to pull the equation of state of your choice off of the tape.

On a continuation run there is an even simpler option available--the copy option. If the problem is to be continued with no changes in the constants used in the Generate run, and the copy option has been used, all you need is a deck consisting of four control cards followed by the Execute data package of 1 card (or 26 cards in the MAP version). If, however, you do wish to change some of the initial constants (for instance you may want to increase C4 in order to slow

down the running of the problem), and you have used the copy option, all you need are four control cards followed by the appropriate Generate data cards (in the example just mentioned the appropriate cards would be the START card, REGION card with proper identification, ENDATA card), a $IBSYS card, and the four control cards for the Execute portion, followed by the Execute data package of 1 or 26 cards depending on the version you use.

On the following pages are examples of the deck setups for a start and continuation runs. The start run will be illustrated by Test Case 1, the continuation run will be illustrated by Test Case 2.

CONTROL CARDS

Initial Run for Test Case 1 (all FORTRAN version)

```
$JOB            4193,HAR20F,P5980,5,30,50,C
```
Initial card for all runs at RAND. Used for accounting purposes and also supplies machine operators with output information.
```
$CLOSE          S.SU07,REWIND
$CLOSE          S.SU09,REWIND
$CLOSE          S.SU10,REWIND
```
To insure that units are properly initialized.
```
$IBJOB GEN      MAP,COPY=U10
```
GEN identifies first IBJOB on copy tape for future use in reload program. MAP yields memory map which can be useful if you need to juggle storage space for tabular EOS. Copy tape is on S.SU10.
```
$FILE           'FTC06.',U05,*,TYPE1,SINGLE,BLOCK=128,LRL=128,RCT=1
$FILE           'FTC12.',U09,*,TYPE1,SINGLE,BLOCK=128,LRL=128,RCT=1
```
In order to save space, we have changed the standard file descriptions of U09 and U05 from double to single buffer and from a standard block size of 256 to 128. As a consequence, we need file cards to describe their configurations. U07 and U06 are written by the system in the conventional way so no file cards are necessary.

```
$IEDIT          U07,SRCH
```
Initiates the search of the reel on U07, containing binary subroutines. For the following decks (COMSIZ and HOLWD must be loaded first and second respectively for they are never executed and contain the dimensions and BCD labels of all zone variables).

```
$IBLDR COSIZG
$IBLDR HOLWD
$IEDIT          IN
```
Allows the user to insert any source or binary decks which he might want to add. (This usually means his own equations of state but can include any subroutine he might want to modify.) If you want to use equations of state which are on the EOS tape, instead of $IEDIT IN you would use $IEDIT U06,SRCH followed by the appropriate $IBFTC cards and ending with $IBLDR ALIBI. Any AIR EOS labeled $IBFTC AIBO __ from U06 requires the data from $IBMAP AIDATA on U06. Thus, the AIR EOS is not available to the all-FORTRAN user without some alteration in the reading in of the appropriate constants.

```
$IBLDR GMAIN
$IBLDR GENRAT
$IBLDR STREAD
$IBLDR CYCRED
$IBLDR TMREAD
$IBLDR GEOM
$IBLDR RMREAD
$IBLDR EOSNRD
$IBLDR REGNRD
$IBLDR ZONGEN
$IBLDR PEKG
$IBLDR FINDC
$IBLDR SOURCE
$IBLDR BOUND
$IBLDR COMP
$IBLDR TMPRD
$IBLDR PERC
$IBLDR FP1001
$IBLDR FE1001
```

```
$IEDIT        U07,SRCH
$IBLDR RESTRT
$IBLDR REOST
$IBLDR ZNGET
$IBLDR GRIDGN
$IBLDR ANEOS
$IBLDR GTVARG
$IBLDR GVRTBG
$IBLDR GETTV
$IBLDR JHTU
$IBLDR IKAERR
$IBLDR ALIBI
$IBLDR FP1000
$IBLDR FP1001
$IBLDR FP1002
$IBLDR FP1003
$IBLDR FP1004
$IBLDR FP1005
$IBLDR FE1000
$IBLDR FE1001
$IBLDR FE1002
$IBLDR FE1003
$IBLDR FE1004
$IBLDR FE1005
$IBLDR FK1000
$IBLDR FK1001
$IBLDR FK1002
$IBLDR FK1003
$IBLDR FK1004
$IBLDR FK1005
$IBLDR DROA
$IBLDR DPET
$IBLDR DTSR
$IBLDR DROAXP
$IBLDR DTSRXP
$IBLDR DCDR
$IBLDR DROAMP
$IBLDR DROB
$IBLDR DROC
$IBLDR DRDI
$IBLDR DROD
$IBLDR DROE
$IBLDR DTSRMP
$IBLDR DRBND
$IBLDR DPBND
$IBLDR DZNSRF
$IBLDR DRGSRF
$ENTRY         GMAIN
```

For $IEDIT U07,SRCH:
$IBLDR "deck name" is a flag to the IEDIT routine to find the deck called "deck name" on the master file. If the $IBLDR cards are arranged in the same order as the binaries on the master file, time will be saved.

You may include any information you may want for documentation purposes between $ENTRY GMAIN and the start card. The only restriction is there must be a data card with an (I6) format (in cols.1-6) to indicate how many cards are used for this documentation purpose.

30   Data card with the (I6) format to indicate how many documentation cards follow up to the START card. A $ sign may not be used in column 1 or any of the documentation cards.

HAROLD TEST 1.

IDEAL GAS

EQUATIONS OF STATE FOR THE GENERATOR.

```
        FUNCTION FP1001(E,V)          This is the source deck
        FP1001= .4*E/V                corresponding to the binary
        RETURN                        deck $IBLDR FP1001.
        END

        FUNCTION FE1001(E,V)          This is the source deck
        FE1001= .139*E                corresponding to the binary
        RETURN                        deck $IBLDR FE1001.
        END
```

EQUATION OF STATE FOR THE EXECUTOR

```
        SUBROUTINE PET(MAT,T,V,P,E,J,C) This is the source deck
        P = .4*E/V                      corresponding to the binary
        RETURN                          deck $IBLDR PET 20.
        END
```

Generate Data for Test Case 1.

```
START      INS=0.        NF=614.
HISTOR      DT=   .025    CT=   1.00
PRINT       ND=  1.       NC=  3.       ND=  7.      NC=  10.
            ND=  40.      NC=  250.     ND=  13.     NC=  263.
            ND=  1.       NC=  264.     ND=  50.     NC=  614.
ENERGY      ND=  1000.    NC=  10000.
TIME S      DT=    .0001  DT=  .0002
RMIN        R=     1.
REGION  2001J=   30.      DR=   .01     T=   .0293   RH=   .0011
            C1=   6.      C2=   0.      C3=   1.6    C4=   16.
            C5=   0.
BOUNDA      OP=    .1
COMBIN      J0=  5.       JS=  0.       JM=  23.     DR= -.76923E-02
ZTEMPE      Z1=   0.      Z2=    .0001  JL=  29.
PERCEN      X1=   0.      X2=   0.      X3=   0.     X4=   .4    -05
            X5=   .125    X6=   .1   -03
```

ENDATA - Signifies end of Generate data and end of Generate section of HAROLD; the $IBSYS card transfers control to the system monitor and prepares for new control cards. This card allows 2 $IBJOB's to be run under the same $IJOB instead of as 2 separate $JOBS.

```
$IBSYS
```

The following cards exactly parallel the arrangement of control cards in Generate.

```
$CLOSE          S.SU07
$IBJOB EXEC     MAP,COPY=U10
$FILE           'FTC08.',U05,*,TYPE1,SINGLE,BLOCK=128,LRL=128,RCT=1
```

```
$FILE           'FTC12.',U09,*,TYPE1,SINGLE,BLOCK=128,LRL=128,RCT=1
$IEDIT          U07,SRCH
$IBLDR COSIZE
$IBLDR EMAIN
$IBLDR EXEC
$IBLDR CLNUP
$IBLDR REQST
$IBLDR ESTAB
$IBLDR SFT
$IBLDR HYD
$IBLDR TSR
$IBLDR JHTU
$IBLDR POR
$IBLDR PPR
$IBLDR HIST
$IBLDR ECHECK
$IBLDR ANEOS
$IBLDR GTVARE
$IBLDR GVRTBE
$IBLDR IKAERR
$IEDIT          IN
```

The same comments apply here as for the Generate section.
Special decks are inserted here as in Generate.

```
$IBLDR ROA
$IBLDR REGSR
$IBLDR ZONSR
$IBLDR PROUT  - Good only for this test case.
$IBLDR CZR
$IBLDR PEKE
$IBLDR FINCC
$IBFTC RBOUND
      SUBROUTINE RBOUND(TMDUM,RHO)
       COMMON /IKA2/ ERS(6,10), ES(6,10), TMRS(6,10), TMS(6,10), RS(10),
     1 JS(10), NRS(10), NZS(10), RRG(15), JREG(15), C1(15), C2(15),
     2 C3(15), C4(15), C5(15), E0(15), EMIN(6), EMAX(6), KMIN(6),
     3 KMAX(6), PMIN(6), PMAX(6), TMIN(6), TMAX(6), UMIN(6), UMAX(6),
     4TEMIN(6), TEMAX(6), TKMIN(6), TKMAX(6), TPMIN(6), TPMAX(6), NKMAX,
     5 TTMIN(6), TTMAX(6), TUMIN(6), TUMAX(6), NEMIN, NEMAX, NKMIN,
     6 NPMIN, NPMAX, NTMIN, NTMAX, NUMIN, NUMAX, NRSRCE, NZSRCE,
     7 JO, JOS, JOM, DRC, Z1, Z2, JL, X1, X2, X3, X4, X5, X6, NS,NF,
     8 UNCGS, UNMKS, TM, DT, DTP, JSTAR, JHAT, JMAX, DELTA, REGNO, JZ,
     9 NREG, NEOS, RMIN, RMAX, IRAD
      COMMON /VLC/VL(1)
      RHO = 1./VL(JMAX)
      RETURN
      END
$IBLDR PET2C
$IBLDR FP1001
$IBLDR FE1001
$IEDIT          U07,SRCH
$IBLDR ALIBI
$IBLDR FP1000
$IBLDR FP1001
```

```
$IBLDR FP1002
$IBLDR FP1003
$IBLDR FP1004
$IBLDR FP1005
$IBLDR FE1000
$IBLDR FE1001
$IBLDR FE1002
$IBLDR FE1003
$IBLDR FE1004
$IBLDR FE1005
$IBLDR FK1000
$IBLDR FK1001
$IBLDR FK1002
$IBLDR FK1003
$IBLDR FK1004
$IBLDR FK1005
$IBLDR DROA
$IBLDR DPET
$IBLDR DTSR
$IBLDR DROAXP
$IBLDR DTSRXP
$IBLDR DCDR
$IBLDR DROAMP
$IBLDR DROB
$IBLDR DROC
$IBLDR DRDI
$IBLDR DROD
$IBLDR DROE
$IBLDR DTSRMP
$IBLDR DRBND
$IBLDR DPBND
$IBLDR DZNSRF
$IBLDR DRGSRF
$ENTRY          EMAIN
     0     1TEST 1. HYDRO ONLY. IDEAL GAS
```

In the MAP version of HAROLD a 25 card packet (called the output description deck) which contains variable output information follows immediately. (See Test Case 2 which uses this 25 card packet.) In the all-FORTRAN version the user must write his own output routine called PROUT, and the output description deck is omitted.

```
$IBSYS
$CLOSE          S.SU07,REWIND
$CLOSE          S.SU09,REWIND
$CLOSE          S.SU10,REWIND
$IBSYS          ENDJOB          TOTAL NUMBER OF CARDS IN YOUR INPUT DECK
```

Continuation Run for Test Case 2.

```
$JOB           4193,HAR27B,WA7950,10,0,75,C
$CLOSE         S.SU06
$IBJOB         NOSOURCE
$RELOAD        U06,NAME=GEN,SRCH
```

The following, with the exception of the START and ENDATA cards which must always be present, are the cards you need to change the constants.

```
START        NS=          131NF=        5000
PRINT OUT    ND=          131NC=         131ND=        29NC=          1
             ND=           30NC=        5000
ENERGY EDIT  ND=          131NC=         131ND=        29NC=          1
             ND=           30NC=        5000
REGION     1C5= 10.
REGION     2C5= 10.
ENDATA
```

Signifies end of first job. If no constants need be altered you do not need the Generate part at all, and to continue running the problem replace the $IBSYS card with the $JOB card and turn in the following 31 cards. If you wish to continue from the last cycle on the history tape set NSTART= to some larger number, say, NF.

```
$IBSYS
$CLOSE         S.SU06
$IBJOB         NOSOURCE
$RELOAD        U06,NAME=EXEC,SRCH

   131     7  10/7/66-HAR. TEST CASE 2-S.P.-IMP.



RADIUS                         FEET                                     4
RADAVG
PVELOC                                FT/SEC                            1
PRESUR                                            PSI                   6
DENSTY           KG/M3                                                  5
INTENG           CAL/GM                                                 2
  TEMPKELVIN                                                            3
TEMAVG
  MASS
DYNPRS                                            PSI                   7
ARTVIS                                            PSI                   8
DELRAD
DEPLET
LMNSTY                KT/SEC                                            9
ROSMFP                         FEET                                    10
ROPCTY
EMSMFP
NETPWR                         CAL/SC                                  11
BBPOWR
RALORT                         CAL/SC                                  12
RADLOS
MOPCTY

$IBSYS           ENDJOB
```

Procedure Cards for I and II*

7040/7044

______ EDP PROCEDURE 90
PAL NO.

FOR OPERATOR'S USE ONLY:

4193	HAR20F	P5980
JOB NO.	RUN I.D.	MAN NO

ABSOLUTE CUTOFF

5	30	60
TOTAL TIME	TOTAL CARDS	TOTAL PAGES

(MUST AGREE WITH JOB CARD)

☐ SIMSCRIPT ☐ 4020

REEL NO	FORTRAN UNIT	SYSTEM UNIT	TSR	FP
Binaries		U07		X
Analytic Eqs.		U06		X
Hist.	12	U09		
Copy		U10		

☐ OVER FOR ADDITIONAL INSTRUCTIONS

7040/7044

______ EDP PROCEDURE 90
PAL NO.

FOR OPERATOR'S USE ONLY:

4193	HAR27B	WA7950
JOB NO.	RUN I.D.	MAN NO.

ABSOLUTE CUTOFF

10	0	75
TOTAL TIME	TOTAL CARDS	TOTAL PAGES

(MUST AGREE WITH JOB CARD)

☐ SIMSCRIPT ☐ 4020

REEL NO.	FORTRAN UNIT	SYSTEM UNIT	TSR	FP
Copy (on U10 for initial run)		U06		
Hist.	12	U09		
Tabular EOS	8	U05		X

The copy tape now contains all binary subroutine and analytic EOS.

☐ OVER FOR ADDITIONAL INSTRUCTIONS

*If tabular equation of state are used, the reel containing the tabular equation of state must be hung on U05 for all runs, initial and continuation.

TEST CASE I

The first test case has thirty identical zones with $\Delta R=.01$, containing ideal gas. The equation of state used is analytic. Since the problem is hydrodynamics only, the equation of state may be of the form P(E,V) and T(E,V), and we have elected to use this form. (Temperature is not necessary in hydrodynamics-only calculations and we intend to conserve computing time by not calculating temperature during execution.) The zones have an initial temperature of 293 degrees Kelvin, and an initial density of .0011 gm/cm^3.

The initial $\Delta t^{\frac{1}{2}}$ is .0002 msec, and Δt^0 = .0001 msec. All input will be in MMEGMS, the units in which the problem is calculated. The geometry is plane geometry. R_0^0 must be non-zero since there is a continuous left hand boundary condition of $P^0_{-\frac{1}{2}}$ = .1 (1 kbar). The choice of R_0^0 = 1. is arbitrary. We will expect a shock front to move from left to right through the thirty zones. We wish to begin combining and adding zones when the shock front reaches the 29th zone. The first two zones to be combined will be zones 6 and 7 and the zone added will have a Δr of .033 times $R_{\hat{j}}$. Zones will be combined out to zone 23 at which time zones 1 and 2 will be combined.

Since temperature will not be calculated at every cycle, we must use a velocity condition to determine $\hat{j}$. All zones whose left hand boundary has a velocity greater than .0001 will be calculated.

X1, X2, X3 and C5 are 0 since they are not used in hydrodynamics-only calculations and X4, X5, X6, C1, C2, C3 and C4 will have our usual values.

The first 40 cards are for documentation of the problem. They are read and printed to insure that a record of the equation of state is included in the output.

START Card

NS is 0 since we are generating a new problem. NF is 614. Since the problem is hydrodynamics only IHYD is set non-zero.

HISTORY EDIT Card

History edits are desired every 50 cycles.

PRINT OUT and ENERGY EDIT Cards

The first five cycles are to be printed, then every 50 cycles until the first doubling of zones, then every 50 until the end of problem.

TIME STEP Card

The first DT must be .0001 (Δt^0) and the second DT must be .0002 ($\Delta t^{\frac{1}{2}}$) since the order of these two is significant.

GEOMETRY Card

No GEOMETRY card is included since plane geometry is desired and is assumed unless otherwise specified.

RMIN Card

$R_0^0 = 1$. So this card is required.

EOS Card

There are no tabular equations of state so this card is omitted.

REGION and ZONE Card

We assign the analytic equation of state the number 2001 since we will use the form P(E,V), T(E,V) for the equation of state (any number between 2000 and 2005 would have been alright). All zones in the region are similar so they may be defined completely on the REGION card. No ZONE card will be required. Any two of the three numbers $\mathcal{J}_{IR}$, $\mathbb{R}_{IR}$ and $\Delta\mathbb{R}_{IR}$ are sufficient to define the zoning. Since $\mathcal{J}_{IR} = 30$ and $\Delta\mathbb{R}_{IR} = .01$ are given we will input these two with the labels J= and DR=. T and P are sufficient to define the remaining zone variables and are input with the labels T= and RH=. T is input as .0293 since the units on MMEGMS. Since E0, C2 and C5 are to be zero, we need only input C1, C3 and C4 to complete the REGION card.

ZSOURCE and RSOURCE Cards

There are no energy sinks or sources in the problem,so these cards are not required.

BOUNDARY Cards

We have a boundary condition P = .1. We specify "MIN" on the card to indicate that the boundary condition is at $j=-\frac{1}{2}$ and use the label P= to specify that it is a pressure boundary condition. Since the boundary condition is continuous throughout the problem, we need specify only the value of P. (The TM, the time at which to change values of the step function, is automatically set very large.)

COMBINATION Card

$j_o = 5$, jos = 0 and jom = 23 and these are input through the labels JO=, JS= and JM= respectively. The ΔR of the zones to be added is a percent of $R_{\hat{j}}$ rather than the actual ΔR of the zone to be added so it is entered as -.033. The label DR= is used.

ZTEMPERATURE Card

Z2 is chosen as .0001 and $j\ell$ is chosen as 29. Z1 is not input since it is not used in hydrodynamics only calculations.

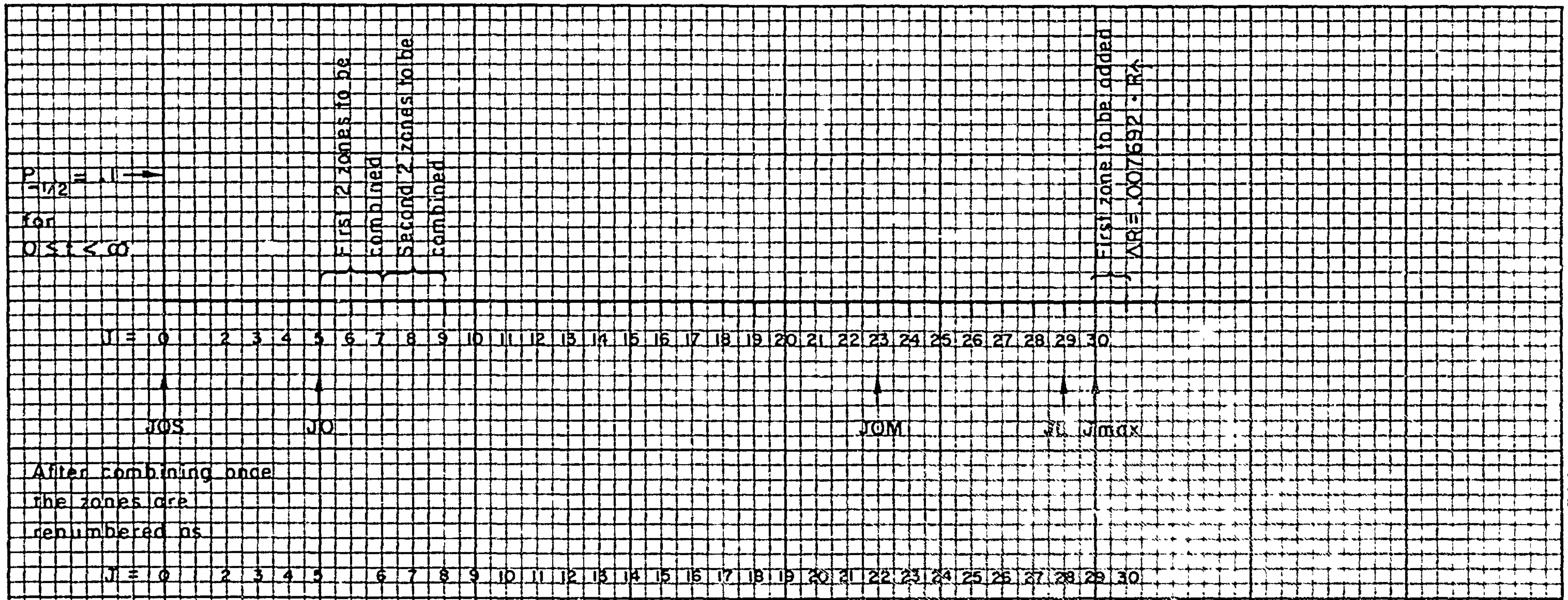
PERCENTS Card

X1, X2 and X3 are omitted since they will not be used. X4, X5 and X6 are assigned their usual value.

ENDATA Card

The ENDATA card must always occur last.

Two function type subroutines are required for the inputting of the equations of state P(E,V) and T(E,V). P(E,V) is included through the subroutine FP1001 and T(E,V) is included through the subroutine FE1001. 1001 is used since 2001 was the material number assigned to the material on the REGION card. The equations of state are: $P(E,V) = \frac{.4E}{V}$ and $T(E,V) = .139\ E$.



R_0 = 1.0 meters

J = Jmax = 30

R = Radius of region = $R_0 + \Delta R \cdot J$ = 1.3 meters

$T_{J-1/2} = .0293 \cdot 10^{4}\ ^{\circ}K \qquad 1 \le J \le 30$

$\rho_{J-1/2} = .0011$ grams/cc $\qquad 1 \le J \le 30$

$\Delta t^{0} = .0001$ msecs

$\Delta t^{1/2} = .0002$ msecs

Fig. 4 - Zone layout, boundary and initial conditions for Test Case I

INPUT DATA AND SUBROUTINES INCLUDED FOR EXECUTE PART OF TEST CASE 1

Restart Card: This problem will be started at cycle 0 so NS is 0. Hydrodynamics only is desired so IRAD is 1.

The variables desired as output are R_j, U_j, $\rho_{j-\frac{1}{2}}$, $T_{j-\frac{1}{2}}$, $E_{j-\frac{1}{2}}$, $P_{j-\frac{1}{2}}$, $Q_{j-\frac{1}{2}}$ and $\Delta m_{j-\frac{1}{2}}$ in that order. All variables will be printed in MMEGMS, the problem units. In RAND version this output is defined by the output description deck (p.253); in FORTRAN version by PROUT (p.362).

Since the equations of state are of the form P(E,V) and T(E,V), the subroutine PET is included. T will only be calculated at output time rather than at every cycle since the problem does not require it. The expression for P(E,V) is

$$P = .4E/V.$$

COUT7,* the COUT routine corresponding to temperature, must be altered to calculate T from E since it is not calculated at every cycle. The expression for T(E,V) is

$$T = .139E.$$

---

*The COUT7 routine is unavailable in all-FORTRAN versions. In all-FORTRAN versions, this manipulation is carried out in PROUT.

CHECK LIST

GENERATOR

1. Correct equations of state?
   If tabular, mount TABCOE tape on S.SU05.
2. Correct JHT subroutine?
   Deck JHTT if Z2 is a temperature
   Deck JHTU if Z2 is a velocity
3. a. COMSIZ and HOLWD first and second.
   b. ALIBI last (RAND version)?
4. History tape on S.SU09.
*5. Copy tape on S.SU10, binaries on S.SU07.
*6. Analytic equation of state tape on S.SU06.

EXECUTOR

1. Correct equations of state?
   If tabular, mount TABCOE tape on S.SU05.
2. a. COMSIZ first?
   b. ALIBI last (RAND version)?
3. History tape on S.SU09.
4. If hydrodynamics only, correct PET deck?
   correct JHT deck?
5. All necessary COUT decks present (RAND version)?
6. For hydrodynamics only, ROA and TSR present?
7. For explicit radiation, CDR, ROAEXP and TSREXP present?
8. For implicit radiation, CDR, ROAIMP, ROB, ROC, RDI, ROD, ROE, TSRIMP present?
9. For non-step sinks and source, RGSRFN and/or ZNSRFN present?
10. For non-standard combining, PBOUND and RBOUND present?
*11. Copy tape on S.SU10, binaries on S.SU07.
*12. Analytic equation of state tape on S.SU06.

---

*5 and 11 apply only if you are using the copy option; 6 and 12 apply only if you are getting your analytic equations of state from a tape.

X. CONCLUSIONS AND RECOMMENDATIONS

The objective has been to anticipate and accommodate more or less automatically a number of frequently used variants in formulating problems. The inevitable consequence of such generality is to confront the user with much more code and more subroutines than any one problem is likely to need. We hope that we have struck a useful balance between complete generality and direct and bare-bones simplicity, but only continued use and modification can sharpen the tool.

The learning time for such a complex set of program alternatives is likely to be several months, during which time the test problems and other trial runs should provide the "student" with an appreciation of the possibilities, as well as of the pitfalls. <u>There is no substitute for careful attention to results</u>. After selecting printout variables and forms, it is foolish not to spend the time scanning <u>every number</u>. It is a rule born of sad experience that one should understand and explain every significant change in every variable. Where a "mysterious" number occurs, if overlooked or ignored, much machine time and many pages of useless output may be cranked through before the seriousness of an error can be fully appreciated. To this end, we have found it helpful to run long problems in short sections, reviewing the results of each partial run, making selections of more appropriate stability or zone-doubling constants, and re-running or hand checking as indicated.

Appendix

GLOSSARY

Subroutine		
TSR	AMBDA	The artificial viscosity time stability conditions = Lambda (see C4).
GETTV	AMP	Convergence criterion for ΔT and ΔV in GETTV. If $(\Delta T^2 + \Delta V^2) <$ amp they are considered to have converged.
BOUND	BDRYSW	Has 2 values: 1 if minimum boundary condition; 2 if maximum.
BOUND	BTYPE	Has 5 values: 1 = E, 2 = K, 3 = P, 4 = T, 5 = U, corresponding to the function which has a minimum or maximum boundary condition.
GMAIN	C	Limit, local variable in CZR, location of first coefficient in tabular EOS.
HYD	C1(15)	Amplitude of quadratic term of artificial viscosity equation in HYD - input on region card.
HYD	C2(15)	Amplitude of linear term of artificial viscosity equation in HYD - input on region card.
TSR's	C3(15)	Multiplicative constant in Omega, the Courant stability condition; C3=largest expected effective specific heat (γ=1 + PV/E) (see text Sec. II) $\Delta t^2 \sim 1/C3$. Input on region card.
TSR's	C4(15)	Multiplicative constant in Lamda - the artificial viscosity stability condition; C4 $\geq$ 4C1 - input on region card (see text).
TSRIMP, TSREXP	C5(15)	Multiplicative constant in Gamma, the radiation diffusion stability condition; C5 = 1 for explicit: for implicit radiation, may have any value - input on region card (see Eq. 51 of text).
REGNRD	C1SWCH	Set non-zero if C1 stability constant is input on region card.
REGNRD	C2SWCH	Set non-zero if C2 is input on region card.
REGNRD	C3SWCH	Set non-zero if C3 is input on region card.
REGNRD	C4SWCH	Set non-zero if C4 is input on region card.
REGNRD	C5SWCH	Set non-zero if C5 is input on region card.

ROC	CAPC(J+1)	$= C^{n+1}_{j-\frac{1}{2}}$. Coefficient for forward-backward substitution; see Eq. 20.
ROC	CAPJ(J+1)	$= J^{n+1}_{j}$. See Eq. 28.
ROC	CAPK(J+1)	$= K^{n+1}_{j-\frac{1}{2}}$. See Eq. 23.
ECHECK	CKC	The ratio of steradians to 4184.6 jerks/kiloton.
ECHECK	CKE(I)	Net internal energy summed over all zones in a region, i.e., the internal energy minus the initial energy.
ECHECK	CKES	Internal energy summed over all regions in the problem.
ECHECK	CKK(I)	The kinetic energy of a region.
ECHECK	CKKS	Kinetic energy summed over all regions in the problem.
ECHECK	CKW(I)	The sum of the internal energy (CKE) and the kinetic energy (CKK) for a region.
ECHECK	CKWS	The total energy of the problem.
PPR;ECHECK	CKY	Energy loss by radiation thru a region interface (between materials).
ECHECK	CKYO	CKY(IR-1); if IR=1, CKYO=0.
PEK	COE(I)	EOS coefficients from FINDC.
	COMSW	Set non-zero if combination card is encountered in data deck.
CYCRED,EXEC, PPR	CTCK(6)	See DTCK(6).
CYCRED,EXEC, PPR	CTH(6)	See DTH(6).
CYCRED,EXEC, PPR	CTP(6)	See DTPR(6).
CYCRED,EXEC, PPR	CYCSW	"1" if history edit card; "2" if print out card; "3" if energy edit card has been read.
CDR,ROA	D(J+1)	$=D^{n+\frac{1}{2}}_{j-\frac{1}{2}}$. Depletion term (see Eqs. 34,74).
PEK	DE	$=\partial E^{n+1}_{j-\frac{1}{2}}/\partial T^{n+1}_{j-\frac{1}{2}}$. A term in CAPC(J+1), Eq.20.
CDR	DELER	$=R^{n+1}_{j} - R^{n+1}_{j-1} = \Delta R$.
CDR	DELIL	= DELER/FLAM = $\Delta R/\lambda$.
GEOM	DELTA	Has 3 values: 1 = plane geometry, 2 = cylindrical geometry, 3 = spherical geometry.
CZR	DET	Term used in solving a quadratic, defined in CZR subroutine.
ROB	DKDMM(J+1)	$= \frac{1}{2}(\frac{T_{j-\frac{1}{2}}}{T_j})^3$. DKDMTM.

ROB	DKDMP(J+1)	$= \frac{1}{2}\left(\frac{T_{j+\frac{1}{2}}}{T_j}\right)^3 \cdot$ DKDMTM.
ROB	DKDMTM	$=\Delta m_{j+\frac{1}{2}}$ DKMP + $\Delta m_{j-\frac{1}{2}}$ DKMM (amounts to $\Delta m_j \frac{\delta K}{\delta T_j}$ at V_j).
ROB	DKMM	$= \frac{\delta K}{\delta T_j}$ at $V_{j-\frac{1}{2}}$.
ROB	DKMP	$= \frac{\partial K}{\partial T_j}$ at $V_{j+\frac{1}{2}}$.
RDI	DL	δL, a measure of change in luminosity from previous iteration, i.e., measure of convergence, see Eq. 31.
	DMASS(J+1)	$=\Delta m_{j-\frac{1}{2}}$.
	DMESS(J+1)	$=\Delta m_j = \frac{1}{2}(\Delta m_{j-\frac{1}{2}} + \Delta m_{j+\frac{1}{2}})$.
ZONGEN,REGNRD	DMVAL	Region mass.
ZONGEN,REGNRD	DMZAL	Zone mass.
PEK	DP	$= \frac{\partial P}{\partial T}$.
	DR	Input value of delta radius on zone or region card.
COMB	DRC	The delta radius of the zones to be added. If it is negative, its absolute value is the percentage of R(JMAX) which is to be used as the ΔR of the added zone.
REGNRD,ZNGET, GRIDGN	DRSWCH	Set non-zero if the increment of the radius is input on region card.
	DRZWCH	Set non-zero if the radial increment is input on zone card.
TMREAD	DT	Initial half time step input on time step card as the first DT - is modified according to appropriate stability conditions in the corresponding TSR routine.
CYCRED,EXEC, PPR	DTCK(6)	CTCK(6) bles of time intervals and change t es for energy edits, i.e., an energy edit will occur every DTCK(I) milliseconds until CTCK(I) milliseconds.
RDI, ROE	DTEM	δT, a measure of change in temperature from previous iteration, i.e., measure of convergence. See Eq. 33.

CYCRED, EXEC, PPR	DTH(6)	CTH(6), tables of time intervals and change times for history edits, i.e., a history edit will occur every DTH(I) milliseconds until CTH(I) milliseconds.
TSR,ECHECK	DTM1	When Δt is modified in TSR to obtain the time step for the next cycle, the Δt for the current cycle is preserved as DTMI to be used in subroutines which follow TSR during the same time cycle.
TSR,ECHECK	DTM2	Read DTM1 and substitute DTP for DT.
TMREAD	DTP	Initial time step of problem input on time step card as the second DT - is modified according to stability conditions in the appropriate TSR routine.
CYCRED, EXEC, PPR	DTPR(6)	CTP(6) a table of the intervals and change times for printouts, i.e., a print out will occur every DTPR(I) milliseconds until CTP(I) milliseconds.
PPR	DTPS	If DTP is changed in PPR because of edit specifications, it is preserved as DTPS so that the maximum DTP from the preceding cycle is always available for modification by TSR.
PPR	DTS	DT, same argument as DTPS.
	EO(15)	The initial energy in the zones of a region.
REGNRD	EOSWCH	Set non-zero if EO is input on region card.
	EG(J+1)	$=E^{n+1}_{j-\frac{1}{2}}$. New energy. See Eqs. 14,17,18.
	EGM(J+1)	$=E^{n}_{j-\frac{1}{2}}$. Old energy. See Eqs. 14,17,18.
	EL(J+1)	$=L^{n+1}_{j}$. New luminosity. See Eq. 15.
	ELM(J+1)	$=L^{n}_{j}$. Old luminosity. See Eq. 15.
HYD	EMAX(I),	TEMAX(I),I=1, NEMAX. Tables of energies and associated times for upper boundary.
HYD	EMIN(I),	TEMIN(I) I=1, NEMIN. Tables of energies and associated times for lower boundary.
	ERFLAG	Set non-zero, causes message to be printed out, and calls exit if error is found in data.
REGSR	ERS(K,IR)	The value of the energy of the Kth step of the IRth region source.

ZONSR	ES(K,IZ)	The value of the energy of the Kth step of the IZth zone source.
ROAEXP	ES	$= {}^{*}E$. Energy value from calculation.
ROA	ESS	$= {}^{**}E$. Energy value from calculation.
REGNRD	ESWCH	Set non-zero if energy value for region is input.
CDR	ETA	$= V_o/V = \rho/\rho_o$ density ratio (relative to ambient).
REGNRD	EVAL	Region energy input.
ROA	EX	Energy value from previous iteration (used with ESS) to test convergence of energy-pressure iteration from PEK subroutine.
CZR,GENRAT	EZ	Value of energy to be used as initial or pre-disturbance (ambient) energy for a zone (used in energy check sum).
REGNRD	EZAL	Zone energy input.
REGNRD	EZWCH	Set non-zero if zone energy is input.
PEK	F	F is P,E, or K if NQ is 1,2 or 3, respectively and ND is zero; or, F is $\delta F/\delta T$ or $\delta F/\delta V$ if ND is 1 or 2, respectively.
PEK	FD	(FN-F)/FN, percentage change in function, new value over old.
	FIELDN	Has values "1" thru "4" corresponding to the 4 fields containing input values on data cards: 1 for cols.16-27, 2 for cols. 31-42, etc.
CDR	FK	Opacity from PEK.
CDR	FLAM	Mean free path for radiation loss. Is either Rosseland (IRAD=3 or 6) or Planck (IRAD=4 or 7). See pp. 64,65.
PEK	FN	New value of function F.
GETTV	FN1T	$\partial P/\partial T$ used in function inversion (Newton-Raphson method).
GETTV	FN2T	$\partial E/\partial T$ used in function inversion.
GETTV	FN1V	$\partial P/\partial V$ used in function inversion.
GETTV	FN2V	$\partial E/\partial V$ used in function inversion.
PEK,GETVAR	FP	Derivative from PEK w.r.t. T if ND=1, V if ND=2, of P if NQ=1, of E if NQ=2, of K if NQ=3.

ROC	G(J)	Forward substitution coefficient, defined in Eq. 27, p. 12 of text.
TSRIMP, TSREXP	GAMMA	Radiation stability measures X40/X10, see Eq.51,p.20. $\Delta t 8R^{2(\delta-1)}T^{3}(C5K\Delta m^{2}\partial E/\partial T)=\Gamma$.
ROC	H(J)	Poward substitution coefficient defined by Eq. 22, p. 11.
REGNRD	I2000	Has two values: 0 for tabular EOS or analytic EOS of the form F(T,V); 1 for analytic EOS of the form F(E,V).
JHTT,JHTU	IANS	0 if T (or U criterion may be used in hydro only) < Z2, 1 if T(or U) $\geq$ Z2.
EXEC	IC	Counts number of loops thru ROC, RDI, ROD. These routines converge the energy in implicit radiation.
REOST,GTVRTB, FINDC	IBEGC(I,J)	Location of first coefficient in IKACOE tabular EOS of the Ith Eq. (I=1,2,3 for P,E,K) of the Jth EOS.
REOST,GTVRTB, FINDC	IBEGT(I,J)	Location of first temperature in IKACOE tabular EOS of the Ith Eq.
REOST,GTVRTB, FINDC	IBEGV(I,J)	Location of first volume in IKACOE tabular EOS of the Ith Eq.
REOST	ICC	Location of the first coefficient of the Ith equation (i.e., P,E, or K) of the Jth EOS.
PPR	ICK	Controls output of energy edits (if 0, problem continues using Δt generated in TSR; if 1, Δt is adjusted to exact output time as specified by energy edit data card.)
EXEC	ICK2	Flag set in EXEC and transmitted to PPR indicating which pair (of a possible 6) is used to start with in modifying Δt's for energy edits.
REOST	ICS	Location of the last coefficient of the Ith equation (i.e., P,E or K) of the Jth EOS.
ESTAB	IDENT	Represents the name of the variable to be output by PROUT as indicated on the output description deck (last 25 data cards in Execute).
EXEC	IDENT	Problem identification.
[illegible]OST,GT[illegible]TB, [illegible]	IDEOS	The ID number of an equation of state (tabular).
REOST	IEOS	The ID number of an equation of state (tabular) on the TABCOE tape.

PPR	IH	See ICK, and substitute "history edit" for "energy check."
PPR	IH2	See ICK2, and substitute "history" for "energy check."
STREAD	IHYD	Has 2 values: 0 (or blank) for problems with radiation; non-zero for hydrodynamics only. Input on START card.
REOST	INO	A counter, the ultimate value of which is equal to the total number of tabular EOS; used as tabular EOS index.
REOST	IORDER(INO)	A table containing the identification number of the INOth EOS.
PPR	IP	See ICK and substitute "print out" for "energy check."
PPR	IP2	See ICK2 and substitute "print out" for "energy check."
ESTAB	IPOS	Position number of the related variable to be output by PROUT as specified in the output description deck (see IDENT). (Not used in all-FORTRAN version.)
	IR	Index for region variables, e.g., C2(IR) is the C2 for the IRth region.
START CARD (EXEC)	IRAD	See Sec.VI data description. Selects type of radiation treatment (IRAD=1 for hydro only), (IRAD=2,3 or 4 explicit with different loss forms), (IRAD=5,6, 7 implicit with different loss forms).
RDI	IRETRN	Has 2 values: "1" indicates further looping thru ROC, RDI to affect δL, δT, T convergence; "2" indicates satisfactory convergence for all quantities in all zones.
RDI	IS1	Has 2 values: "1" indicates δL, L convergence and → IRETRN=2; "2" indicates at least one zone has a non-convergence in δL, or L so IRETRN=1 and further looping thru ROC is called for.
RDI	IS2	Has 2 values: "1" indicates δT,T convergence and IRETRN=2. See IS4.
RDI	IS3	Has 2 values: "1" indicates δL, L convergence and IRETRN=2. See IS1.
RDI	IS4	Has 2 values: "1" indicates δT, T convergence and → IRETRN=2; "2" indicates at least one zone has non-converging δT or T and further looping thru ROC is called for.

ESTAB	ISIG	The number of significant figures desired for the related variable as specified in the output description deck (see IDENT). (Not used in all-FORTRAN version.)
CLNUP	ISSW5	Is "0" until an interval timer overflow occurs when it is set to one. It is checked in EXEC at the end of each cycle. If it is "1" history edit and printout occurs. (A dummy CLNUP subroutine is used in the all-FORTRAN version.)
EOSNRD	ISUB	IDEOS(ISUB) is a table containing the identification number of the EOS corresponding to (ISUB-1) on the EOS card.
REOST,GTVRTB	ITAB	ITAB 1 corresponds to P; 2 to E; 3 to K and tabular EOS are indexed IBEGT (ITAB,INO).
REOST	ITABNO	Has values 1, 2 or 3 corresponding to P, E, or K, respectively.
REOST	ITC	Location of first temperature in the Ith equation (P,E or K) of the Jth equation of state.
ESTAB	ITEM	Has integer values for "1" to "25" which are associated with a particular variable, e.g., (1 = radius, 3 = velocity, 7 = temperature) in the output description deck (see p.253). (Not used in all-FORTRAN version.)
REOST	ITOTC	Total number of coefficients associated with the Ith equation (i.e., P,E or K) of the Jth EOS.
REOST	ITS	Location of the last temperature in the Ith equation (i.e., P,E or K) of the Jth EOS.
ESTAB	IUNTS(I)	The units which you choose the associated variable to be output in by PROUT as specified in the output description deck (see IDENT). (Not used in all-FORTRAN version.)
REOST	IVC	Location of the 1st vol. in the Ith equation (i.e., P,E or K) of the Jth EOS.
REOST	IVS	Location of the last vol. in the Ith equation (i.e., P,E or K) of the Jth EOS.
ZONSR	IZ	A counter, the ultimate value of which is equal to NZSRCE; i.e., the total number of zone source functions in the problem.

COMB,CZR	JC	When the shock front reaches JL (i.e., when JHAT=JL) zones are combined beginning with JO and JO+1.
COMB,CZR	JOM	Zones are combined between JO and JOM. JOM is the last zone to be combined.
COMB,CZR	JOS	When JO reaches JOM it is reset to JOS and then zones are combined between JOS and JOM.
GE'	JEO	If EO is input as a negative number on the region card, JEO=JREG(IR)+1 (JMAX of IRth region) and the initial or ambient energy of the IRth region is taken as EG(JEO).
TSRIMP	JGAMMA	The value of J for which GAMMA is the largest, i.e., the zone in which the most critical value of GAMMA exists.
	JHAT	The last zone of hydrodynamic interest, or the last zone for which the value of T (or U) is greater than or equal to Z2.
TMPRD	JL	When JHAT reaches JL (or the shock front reaches JL) the combining and adding of zones begins.
TSR'S	JLAM	The value of J for which LAMBDA is the largest, i.e., the zone in which the most critical value of LAMBDA exists.
	JMAX	The total number of zones in the problem. JREG(NREG).
TSR'S	JOMEGA	The value of J for which OMEGA is the largest, i.e., the zone in which the most critical value of OMEGA exists.
GRIDGN	JORIG	The first zone in each region or the J value at which the next block of zones (specified by a zone card) begins.
	JREG(IR)	JMAX of the IRth region, i.e., if there are NREG regions in the problem, JREG (NREG)=JMAX.
SOURCE	JS(IZ)	Zone number into which the IZth source goes.
	JSTAR	The last zone of interest in radiation problems, or the last zone for which the value of T is greater than or equal to Z1.

REGNRD	JSWCH	Is set non-zero if the maximum J value for the region is input.
ROD	KDM(J)	$=(k\Delta m)^{n+1}_{j-1}$. See Eq. 16.
ROD	KM(J)	$=K^{n+1}_{j,j-\frac{1}{2}}$, i.e., $K(T_j,V_{j-\frac{1}{2}})$. See Eq. 16.
BOUND	KMAX(I)	TKMAX(I) I=1, NKMAX. Tables of opacities and associated times for upper boundary.
BOUND	KMIN(I)	TKMIN(I) I=1, NKMIN. Tables of opacities and associated times for lower boundary.
ROD	KP(J)	$=K^{n+1}_{j,j+\frac{1}{2}}$, i.e., $K(T_j,V_{j+\frac{1}{2}})$. See Eq. 16.
REGNRD,ZONGEN	KSWCH	Is set non-zero if opacity for a region is input.
REGNRD,ZONGEN	KVAL	Is the region opacity applies to all zones in a region.
REGNRD,ZONGEN	KZAL	Is the zone opacity.
REGNRD,ZONGEN	KZWCH	Is set non-zero if the zone opacity is input.
ANEOS	LA	By the time you get to ANEOS all material numbers are designated by 1000 to 1005 inclusive. Since LA is defined as (material number-999) it always has integral values 1 thru 6 inclusive.
GMAIN	LIMIT	The maximum allowable storage space for tabular EOS.
FINDC	LOOK	=IDEOS(ISUB). See ISUB.
	MA	The material number of the region.
	MAT(J)	Material number of the Jth zone.
EOSNRD	MEOS	A counter, the ultimate value of which is equal to the total number of tabular EOS used in the problem.
GETVAR	MF	Has 3 values: 1 corresponds to P, 2 to E, and 3 to K.
UNTRED	MMEGMS	Problem units (meters, megagrams, milliseconds).
REGNRD,ZONGEN	MSWCH	Is set non-zero if the region mass is input.
REGNRD,ZONGEN	MZWCH	Is set non-zero if the zone mass is input.
	N	Cycle number.

PPR, CYCRED	NCKC(6)	Table of final cycles in an interim specified on energy edit card, i.e., energy edit occurs every NDCK(I) until NCKC(I).
GETVAR	NCOT	Iteration counter used to terminate looping at NCOT=22, to interrupt averaging at 16th iteration, and to initiate a print.
GETTV	NCSW	It is zero thru ten iterations which attempt to converge on Δtemp; on the 11th loop it is set to 1 causing a printout to occur until the 15th pass, at which time you give up and call exit.
PPR,CYCRED	NDCK(6)	Table of cycle intervals specified on energy edit card.
PPR,CYCRED	NDH(6),NHC(6)	Table of cycle intervals and change cycles as specified on history edit card, i.e., history edits occurs every NDH(I) cycles until NHC(I).
PPR,CYCRED	NDP(6),NPC(6)	Table of cycle intervals and change cycles as specified on printout card, i.e., printouts occur every NDP(I) cycles until NPC(I).
BOUND,HYD	NEMAX	The number of maximum energy boundary conditions.
BOUND,HYD	NEMIN	Number of minimum energy boundary conditions.
PPR	NENCK	The value of N at which the next energy edit will occur.
REGNRD	NEOS	The material number of the region (see Sec.V region card discussion).
STREAD	NF	The final cycle to be calculated as specified on start data card.
RESTRT	NFT	=NF. Final cycle to compute as specified on start card in Generate data.
PPR,CYCRED	NHC(6)	See NDH(6).
PPR	NHIST	The value of N at which the next history edit will occur.
BOUND,HYD	NKMAX	The total number of maximum opacity boundary conditions.
BOUND,HYD	NKMIN	The total number of minimum opacity boundary conditions.
REOST	NOTS	Number of temperatures used to define function values in a tabular EOS.

REOST	NOVS	Number of volumes used to define function values in a tabular EOS. Since all tabular EOS are of the form F(T,V) the total number of function values in the EOS must be NOTS x NOVS.
CYCRED,PPR	NPC(6)	See NDP(6).
BOUND,HYD	NPMAX	The total number of maximum pressure boundary conditions.
BOUND,HYD	NPMIN	The total number of minimum pressure boundary conditions.
EXEC,PPR	NPRT	The value of N at which the next print out will occur.
REGSR	NR	NR is in the calling sequence of REGSR and represents the number of the region currently being worked on by the calling subroutine.
	NREG	The total number of regions in the problem.
REGSR	NRS(IR)	The number of steps in the IRth region source function.
REGSR	NRSRCE	The total number of region source functions.
STREAD	NS	The cycle at which to start calculating as specified on start card. If NS is a large number (say greater than NF) the problem will begin from the last cycle on the history tape.
EXEC	NSTART	Start cycle number on Execute section of card.
BOUND,HYD	NTMAX	The total number of maximum temperature boundary conditions.
BOUND,HYD	NTMIN	The total number of minimum temperature boundary conditions.
BOUND,HYD	NUMAX	The total number of maximum velocity boundary conditions.
BOUND,HYD	NUMIN	The total number of minimum velocity boundary conditions.
GETVAR	NV	Has value 1 if T is the independent variable, or 2 if V is the independent variable.
ZNGET	NZ	Counter in ZNGET the ultimate value of which is equal to NZONE.
REGNRD,ZNGET, ZONGEN	NZONE	The number of consecutive zones for which the information on the zone data card is true (see Sec. V discussion of zone cards).

SOURCE,ZONSR	NZS(IZ)	The number of steps in the IZth zone source function.
ZONSR	NZSRCE	The total number of zone source functions.
TSR'S	OMEGA	Hydrodynamic stability measure $(X20)\cdot(X40)^2$, see Eq.49, p.20, $\Omega = \Delta t^2 R^{2(\delta-1)} PC_3/(V\Delta m^2)$.
GETVAR	OVAR	The "other" independent variable (T or V) to be returned by GETVAR.
GETVAR	OVARP	Previous value of OVAR in convergence loop.
ROAEXP	P12	$=PR^{n+\frac{1}{2}}_{j-\frac{1}{2}} = \frac{1}{2}(PR^{n}_{j-\frac{1}{2}} + PR^{n+1}_{j-\frac{1}{2}})$, time average of pressure (between n and n+1).
GENRAT	PERCSW	Set non-zero if percents card is encountered.
BOUND,HYD	PMAX(I),	TPMAX(I) I=1, NPMAX. Tables of pressures and associated times for upper boundaries.
BOUND,HYD	PMIN(I),	TPMIN(I)I=1, NPMIN. Tables of pressures and associated times for lower boundaries.
	PR(J)	$=P^{n+1}_{j-\frac{1}{2}}$. New pressure.
	PRM(J)	$=P^{n}_{j-\frac{1}{2}}$. Old pressure.
REGNRD,ZONGEN	PSWCH	Set zero if pressure for a region is input.
REGNRD,ZONGEN	PVAL	Region pressure.
REGNRD,ZONGEN	PZAL	Zone pressure.
REGNRD,ZONGEN	PZWCH	Set non-zero if pressure for a zone is input.
	Q(J)	$=Q_{j-\frac{1}{2}}$. Artificial viscosity. (Eq. 13.)
	R(J)	$=R^{n}_{j}$. Radius. See Eq. 11.
REGNRD	REGNO	If used as a counter its ultimate value is equal to NREG, otherwise it corresponds to NEOS.
REGNRD	RGNSW	Set non-zero when region card is read.
REGNRD,ZONGEN	RHSWCH	Set non-zero if region density is input.
REGNRD,ZONGEN	RHVAL	Region density.
REGNRD,ZONGEN	RHZAL	Zone density.
REGNRD,ZONGEN	RHZWCH	Set non-zero if zone density is input.
	RMAX	Maximum radius in the problem.
	RMIN	Minimum radius in the problem.

	RRG(15)	A table of outer radii of regions.
SOURCE,REGSR	RS(IR)	Region number into which the IRth source goes.
REGNRD,ZNGET	RSWCH	Set non-zero if radius is given for region.
REGNRD,GRIDGN	RVAL	Radius of a region.
	RZWCH	Set non-zero if zone radius is given.
ROC	SAG	An implicit radiation forward substitution coefficient (see Eq.24 of text, p. 12).
RGSRFN, ZNSRFN	SFN	The value of the energy in the analytic source function.
ROE,ROC	SIG(J)	An implicit radiation forward substitution coefficient (see Eq.19 of text, p.11).
TSR	SL1	Flag set non-zero if Δt has been modified.
REGSR,CDR	SR	In calling sequence of REGSR. In REGSR SR=ERS(K,IR)+SFN. It is returned to the calling subroutine as the total energy source (step and analytic) of the region.
SOURCE	SRCESW	Has value 1 for zone sources, and 2 for region sources.
ECHECK	SUM1	The sum of the internal energy of the region in jerks/steradian.
ECHECK	SUM2	The sum of the masses in a region (the total mass per steradian of a region). When multiplied by the initial energy of the region it is used to compute CKE(IR), the net internal energy of IR.
ECHECK	SUM3	The sum of the kinetic energy of the region.
CDR	SUMDL	Accumulated sum of DELIL, i.e., $\sum_{j=JSTAR}^{j} \Delta R/\lambda$ (see Sec.IV, pp.64-65).
ZONSR,CDR	SZ	In calling sequence of ZONSR. In ZONSR SZ=ES(K,IZ)+SFN; It is returned to the calling subroutine as the total energy source (step and analytic) of the zone.
ESTAB	TAB(,)	Tables containing the output information from the output description deck. In particular TAB(2,IF) contains conversion factors if output is to be in units other than MMEGMS.

	TAM(J+1)	Average temperature = $\left[\frac{1}{2}[(T^{n+1}_{j-\frac{1}{2}})^4+(T^{n+1}_{j+\frac{1}{2}})^4]\right]^{\frac{1}{4}}$ $= T^{n+1}_{j}$.
	TEM(J+1)	$=T^{n+1}_{j-\frac{1}{2}}$.
	TEM3(J+1)	Temperature raised to the 3rd power $(T^{n+1}_{j-\frac{1}{2}})^3$.
	TEM4(J+1)	Temperature raised to the 4th power $(T^{n+1}_{j-\frac{1}{2}})^4$.
	TEMSQ(J+1)	Temperature squared $(T^{n+1}_{j-\frac{1}{2}})^2$.
PEK	TDIF	Arbitrary temperature change (for derivatives) = $.0001 \cdot T^{n+1}_{j-\frac{1}{2}}$.
BOUND,HYD	TEMAX(6)	See TMAX(I).
BOUND,HYD	TEMIN(6)	See TMIN(I).
ROC,CDR,PPR	THETA(J+1)	Loss term for radiation: $\theta^{n+\frac{1}{2}}_{j-\frac{1}{2}} = 2 \cdot D^{n+\frac{1}{2}}_{j-\frac{1}{2}}$. $\Delta m_{j-\frac{1}{2}} = \sigma T^4 R^{(\delta-1)}(\Delta t)(\Delta R/\lambda) f$ (see p. 65).
CDR	THSMM(IR)	Old value of THSUM(IR) (from previous cycle).
CDR	THSUM(IR)	$= \sum_n \theta^{n+\frac{1}{2}}_{j-\frac{1}{2}}$.
BOUND,HYD	TKMAX(6)	See KMAX(I).
BOUND,HYD	TKMIN(6)	See KMIN(I).
	TM	The time of the current cycle.
BOUND,HYD	TMAX(I),	TTMAX(I), I=1, NTMAX. Tables of temperatures and associated times for upper boundary.
BOUND,HYD	TMIN(I),	TTMIN(I), I=1, NTMIN. Tables of temperatures and associated times for lower boundary.
PPR	TMCKL	= the time at which the next energy edit will occur.
PPR	TMHL	= the time at which the next history edit will occur.
PPR	TMPL	= the time at which the next print out will occur.
SOURCE,REGSR	TMRS(K,IR)	The time corresponding to ERS(K,IR).
SOURCE,ZONSR	TMS(K,IZ)	The time corresponding to ES(K,IZ).
BOUND,HYD	TPMAX(6)	See PMAX(I).
BOUND,HYD	TPMIN(6)	See PMIN(I).

REGNRD,ZONGEN	TSWCH	Set non-zero if region temperature is given.
BOUND,HYD	TTMAX(6)	See TMAX(I).
BOUND,HYD	TTMIN(6)	See TMIN(I).
BOUND,HYD	TUMAX(6)	See NMAX(I).
BOUND,HYD	TUMIN(6)	See NMIN(I).
REGNRD,ZONGEN	TVAL	Region temperature input value.
REGNRD,ZONGEN	TZAL	Zone temperature input value.
REGNRD,ZONGEN	TZWCH	Set non-zero if zone temperature is given.
	U(J)	$=U^{n+1}_{j-\frac{1}{2}}$. See Eq. 8.
BOUND,HYD	UMAX(I),	TUMAX(I), I=1, NUMAX. Tables of velocities and associated times for upper boundary.
BOUND,HYD	UMIN(I),	TUMIN(I), I=1, NUMIN. Tables of velocities and associated times for lower boundary.
UNTRED	UNCGS	Has values 0 or 1. It is 1 if output is in CGS units.
ESTAB	UNI(,)	Table containing output units as specified in output description deck (MAP version only).
UNTRED	UNMKS	Has values 0 or 1. It is 1 if output is in MKS units. (Meter, kilograms, seconds.)
REGNRD,GRIDGN	USWCH	Set non-zero if region velocity is input
REGNRD,GRIDGN	UVAL	Region velocity input value.
REGNRD,ZNGET	UZAL	Zone velocity input value.
REGNRD,ZNGET	UZWCH	Set non-zero if zone velocity is input.
PEK	VDIF	Arbitrary infinitesimal volume change (for derivatives) = $.0001\cdot V^{n+1}_{j-\frac{1}{2}}$.
	VL(J)	$=V^{n+1}_{j-\frac{1}{2}}$. New volume. See Eq. 12.
	VLM(J)	$=V^{n}_{j-\frac{1}{2}}$. Old volume.
REGNRD,ZONGEN	VSWCH	Set non-zero if specific volume of region is input.
REGNRD,ZONGEN	VVAL	Value of specific volume of region input.
REGNRD,ZONGEN	VZAL	Value of specific volume of zone input.
REGNRD,ZONGEN	VZWCH	Set non-zero if specific volume of zone is input.

	WLAB	The temporary name of the card title, variable label or variable value in all Generate subroutines which read and interpret data cards.
ECHECK	WTERM	Net energy of the region.
PERC	X1	See Section V, pp. 117, 118.
PERC	X2	See Section V, pp. 117, 118.
PERC	X3	See Section V, pp. 117, 118.
PERC	X4	See Section V, pp. 117, 118.
PERC	X5	See Section V, pp. 117, 118.
PERC	X6	See Section V, pp. 117, 118.
TSRIMP,TSREXP	X10	2 times DTP.
TSR'S	X20	Used to obtain OMEGA (Ω).
TSR'S	X30	Used to obtain LAMBDA (λ).
TSR'S	X40	Used to obtain GAMMA (Γ).
TSREXP,TSRIMP	X10TRM	Calculated value to be compared with X10 for obtaining new Δt.
RDI	XL	=DL/X2/EL(J+1).
RDI	XT	=DTEM/TEM(J+1).
TSR'S	XX	(Dummy label for X20,X30).
ZTEMP	Z1	See Section V, p. 117, Ztemperature card.
ZTEMP	Z2	See Section V, p. 117, Ztemperature card.
REGNRD(etc.)	ZGETSW	Is set non-zero if further data is needed for region definition.
ZONGEN	ZNQSW	="0" if region data is complete, ="1" if T only given, ="2" if V only given, ="3" if E only, ="4" if P only, ="5" if K only, ="6" if no region variable given, ="7" if mass only supplied.
REGNRD,ZONGEN	ZNSWC	Set non-zero if card is "zone" instead of "region."
GENRAT	ZTEMSW	Set non-zero if Ztemperature card is encountered.

REFERENCES

1. von Neumann, J., and R. D. Richtmyer, J. Appl. Phys., Vol. 21, 1950, p. 232.

2. Brode, H. L., J. Appl. Phys., Vol. 26, June 1955, p. 766.

DOCUMENT CONTROL DATA

1 ORIGINATING ACTIVITY THE RAND CORPORATION	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP
3. REPORT TITLE A PROGRAM FOR CALCULATING RADIATION FLOW AND HYDRODYNAMIC MOTION	
4. AUTHOR(S) (Last name, first name, initial) Brode, H. L., W. Asano, M. Plemmons, L. Scantlin and A. Stevenson	

5. REPORT DATE	6a. TOTAL No. OF PAGES	6b. No. OF REFS.
April 1967	412	2

7. CONTRACT OR GRANT No.	8. ORIGINATOR'S REPORT No.
F44620-67-C-0045	RM-5187-PR

9a. AVAILABILITY/ LIMITATION NOTICES	9b. SPONSORING AGENCY
DDC-1	United States Air Force Project RAND

10. ABSTRACT

A numerical program is presented for solving shock wave and fluid dynamic problems in the presence of radiation flow, which can be adapted to a wide range of dynamic problems. The program is Lagrangian in approach and is capable of calculating hydrodynamic motions, including shocks, in one space dimension: spherical, cylindrical, or plane symmetry. Radiation diffusion, grey-body or other radiation losses, and energy sinks or sources are simultaneously calculable with this code. The study describes the physical models that can be called upon in solving various problems, displays the consequent differential equations, and develops the difference methods employed in the step-wise integration. A variety of initial problem descriptions and boundary conditions can be called upon. Outputs can be in a selected listing or can be taped for automatic plotting and further processing. An all-FORTRAN version is featured as being useful on the widest variety of computing equipment, and a listing of the complete program is supplemented by flow diagrams, example calculations, and suggestions on setting up and running problems.

11. KEY WORDS

Nuclear blasts
Nuclear effects
Weapons effects
Fluid dynamics
Radiation
Computer programs
Hydrodynamics